Appendix F.
Final Approach and Runway Occupancy Awareness (FAROA)

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F.1 Final Approach and Runway Occupancy Awareness (FAROA)

F.1.1 Introduction

F.1.1.1 Background

Airport surface operations include the movement of aircraft and ground vehicles (e.g, snowplows, tugs, personnel transporters, baggage carts) on areas such as ramps, taxiways, and runways. These operations may or may not be directed by air traffic control. In non-movement areas not under air traffic control, flight crews may or may not be issued instructions by ramp control. At airports without Air Traffic Control (ATC), flight crews are required to conduct their own navigation routing. During current surface operations, flight crews navigate the airport surface by use of a paper map and airport visual aids. Out-the-window visuals aids / information includes centerlines, edge lines, lights, signs, other aircraft, other vehicles, different terrain, buildings, taxiways, runways, etc.

The execution of a route involves the local control of the aircraft, which involves maneuvering the aircraft on route (best speed & on centerline). Additionally, the flight crew has a task of global awareness, which involves monitoring position relative to destination and hazards, upcoming hazards, and turns (Lasswell and Wickens, 1995). The airport surface is a complex and very busy environment due the numerous tasks required of the flight crew (e.g., navigating, completing checklists, communicating with company ops) as well as to potential unfamiliarity, non-optimal weather or lighting conditions. For example, poor weather conditions played a role in an accident at Tenerife, Canary Islands. It occurred when two 747s collided on a runway. One aircraft was on an unauthorized takeoff run and collided with the other aircraft back taxing on the same runway. This accident incurred the most fatalities of any accident to date (583 deceased). Additionally, six other surface accidents have occurred since 1990 in the United States: Atlanta, Georgia; Detroit, Michigan; Los Angeles, California; St. Louis, Missouri; Quincy, Illinois, and Sarasota, Florida. Numerous near events have also occurred.

The airport surface has been cited numerous times as a safety concern. For example, the "U.S. Federal Aviation Administration (FAA) Administrator Jane Garvey, speaking at the agency's Runway Safety National Summit conference last year, emphasized that "Taxiing on the airport surface is the most hazardous phase of flight."…when accident statistics-including those of near misses [sic]- were analyzed, today's airport surface was found to have the greatest potential for major catastrophes" (Gerold, 2001). The FAA's Runway Safety Program has a top 10 action item list that includes the assessment of new technologies along with training and other items. Finally, the National Transportation Safety Board (NTSB) has included *Airport Runway Incursions- Provide for safer control of aircraft on the ground* on its Top 10 Most Wanted Transportation Safety Improvements since its inception in 1990.

Although the FAA and industry have made efforts to reduce the number of surface incidents, runway incursions continue to occur (FAA, 2000a). Additionally, as the number of operations at airports increases with the rising demand for air travel, exposure to accidents on or near the runway surface also increases.

This application has its origins in the Minimum Aviation System Performance Standards (MASPS) for Automatic Dependent Surveillance-Broadcast (ADS-B) and is defined as application D.1.16: Runway and Final Approach Occupancy Awareness (RTCA, 1998). The application is also defined at a high level in an appendix in the Safe Flight 21 Master Plan as Operational Enhancement #6: Improved Surface Surveillance and Navigation for the Pilot operational applications 6.1.1 - Runway and Final Approach Occupancy Awareness (Using ADS-B only) and 6.1.2 Runway and Final Approach Occupancy Awareness (Using ADS-B and Traffic Information Service -Broadcast (TIS-B)) (FAA, 2000b). This document will describe application 6.1.2, but it is expected that 6.1.1 will be very similar, if not the same, except for the exclusion of TIS-B information.

Additionally, similar concepts to Final Approach and Runway Occupancy Awareness (FAROA) are documented in the RTCA SC-193 document User Requirements for Aerodrome Mapping Information: A.5 Surveillance and conflict (runway incursion) detection and alerting (RTCA, 2001). For the A.5 concept, FAROA would include alerting for the cockpit side (i.e., not ATC).

F.1.1.2 Operational Purpose

The objective of this application is to increase the flight crew's awareness of aircraft and surface vehicles that are on or near the runway surface or up to approximately 1000 feet above ground level (AGL) on final approach. This would be accomplished through a cockpit display that would include the runway environment and other traffic. The display could be used by the flight crew to help determine runway occupancy and go-around decision-making.

In regards to errors, FAROA is expected to provide the following benefits.

1. Reduce the likelihood of flight crew errors associated with runway occupancy during final approach and landing, takeoff roll, and taxi.

2. Improve the capability of the flight crew to detect their own errors that have already occurred before the error results in an accident. (For example, initiating a takeoff roll on an occupied runway.)

3. Improve the capability of the flight crew to detect ATC errors.

F.1.1.3 Domain

This application is expected to be allowed to be conducted by all types of appropriately equipped aircraft (e.g., military, general aviation, commercial carriers) at sparsely or densely populated, controlled or non-controlled, airports on or near the runway surface and up to approximately 1000 feet AGL on final approach.

On landing, the application begins on final approach and ends when ownship is clear of the landing runway. On takeoff, the application begins prior to ownship entering the runway for takeoff and ends once ownship is airborne. The application is also conducted at any time during taxi when a runway has to be crossed. When FAROA is not being conducted during taxi, the companion application, Airport Surface Situational Awareness (ASSA) can be conducted. FAROA can be performed regardless of ATC surface surveillance equipage1. All aircraft need to be properly equipped to be seen on the SMM2. Normal taxi, takeoff, and landing speeds are expected.

Several different runway incursion scenarios exist and are shown in Figure F-1. Scenario A depicts an aircraft taxiing onto the runway when an aircraft is attempting to land. Scenario B depicts a similar scenario where an aircraft taxies onto a runway when an aircraft is attempting to depart. Scenario C illustrates the condition when there is loss of separation between arriving and departing aircraft using the same runway. Scenario D depicts a conflict between operations on runways that cross. Scenario E depicts a landing situation where an aircraft waiting to be cleared for takeoff has taxied past the holding position.

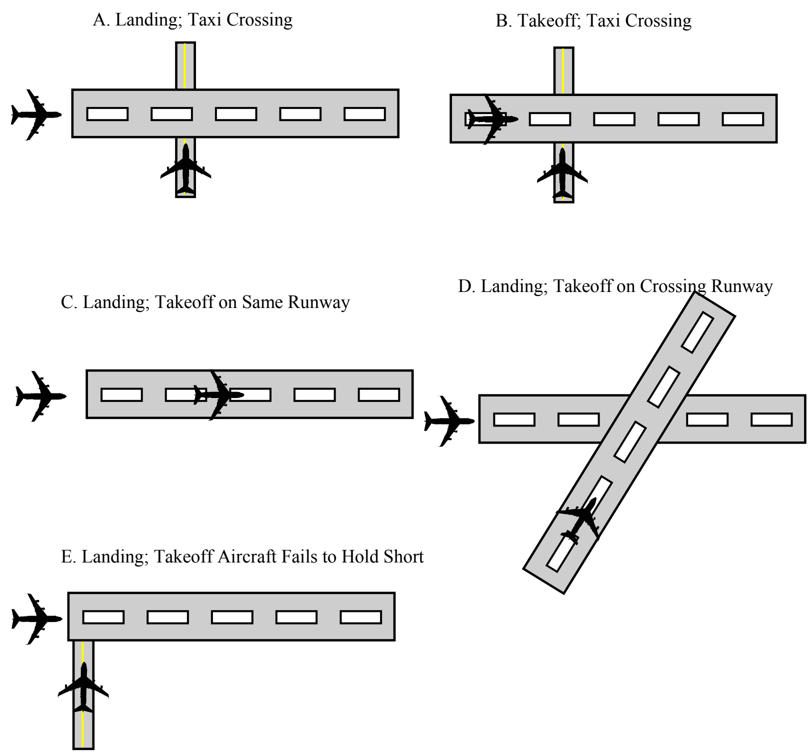


Figure F-1 Potential Incursion Scenarios.

One of the most demanding situations for the FAROA system is illustrated in scenarios A, B, and E above. One would like information from the FAROA application as to whether a traffic vehicle has infringed on the runway, or whether the traffic is safely holding short.

The surface movement applications must consider various possible visibility conditions. The visibility conditions affect the flight crew's ability to see and avoid other traffic during taxi, takeoff, and final approach and landing. In addition, the visibility conditions affect the controller's ability to observe and control traffic. Currently, four classifications

[1] If an alerting scheme is included with the ATC equipment, the cockpit alerting should be compatible with the ATC alerting so that issues do not arise stemming from different alerting schemes.
[2] In an environment where all aircraft are equipped to transmit and receive ADS-B, pilots will be able to see all aircraft unless an anomaly exists. However, in a mixed equipage environment where pilots rely on TIS-B to see all aircraft, ground transmission of traffic information is required.

for visibility conditions have been defined by International Civil Aviation Organization (ICAO) (1997) and are described in the ASSA application (section 1.1.4 of the ASSA appendix).

The flight crew is expected to be able to use the Surface Moving Map (SMM) and the associated traffic information in all of these visibility conditions3. It is assumed that the current operating procedures under each of these visibility conditions are already safe. Flight crews will need some means to navigate in all the visibility conditions. Given that, the SMM with traffic information can augment the existing safe operations by providing supplementary information on the Cockpit Display of Traffic Information (CDTI) that helps the flight crew maintain position and traffic situational awareness. This additional information is expected to provide additional safety benefits.

F.1.1.4 Justification

The main benefit from this application is increased safety through enhanced flight crew awareness of air traffic and ground vehicle position on or near the runway (either airborne below approximately 1000 ft AGL or on the surface), thereby reducing the likelihood of ground collisions or near collisions. This benefit will be particularly valuable at night and during periods of low ceilings or reduced visibility when the flight crew's out-the-window scan is less effective.

F.1.1.5 Maturity and User Interest

Safe Flight 21 has identified FAROA as an important, short-term application, and as part of the FAA Safe Flight 21 Ohio River Valley efforts, the FAROA application was demonstrated during Operational Evaluation 2 in October 2000 (FAA, 2001b). During that evaluation, surface maps were installed in several aircraft and used by flight crews to determine runway occupancy. Additional demonstrations and implementations are also planned..

Rockwell Collins Flight Dynamics, Jeppesen Sanderson, and Smiths Industries are developing a Surface Guidance System (SGS) that will depict taxiway, stop bars, route and other information on a head-up display (HUD). The information will be data linked by ATC to the flight management system (FMS) which will send the necessary information on to the HUD for display.

F.1.2 Operational Concept, Roles, and Procedures

F.1.2.1 Concept Description

The FAROA application includes the depiction of ownship position, traffic position, and a runway layout map on a SMM. The depiction of all taxiways, ramp areas, etc. may or may not be included with the runway layout. The minimum element of the runway environment would be ownship runway of intended use and any crossing runway(s). However, the runway environment could include taxiways near the runway, runway edge lines, hold short lines, etc. (see section F.1.3.1 for further discussion). The SMM could

[3] As with ASSA, in visibility condition 4, the flight crew is required to have some form of assistance to taxi on the airport surface. The SMM for FAROA is not that tool. Nevertheless, the SMM is a potential situational awareness tool during these operations.

be, for example, on a multifunction display, a dedicated cockpit display, or on an electronic flight bag type of display. The SMM may or may not be the same display that is used for in-flight information. The SMM will provide flight crews additional information to enhance landing, takeoff, and runway crossing decisions. It will do so by providing the flight crew with accurate traffic position information so the flight crew is able to determine if the runway is, or soon will be, occupied. The application will provide information on traffic on the runway as well as the airspace around the final approach path from the surface to approximately 1000 feet AGL. The application is not initially expected to require alerts.

The SMM is expected to supplement existing ATC services for the flight crew and to act as a safety net should an ATC or flight crew error occur. Therefore, if the SMM were to fail, flight crews would return to their normal out-the-window scan procedures without the use of the SMM. At airports where ATC services are not available, the visual scan enhanced by the SMM is the only protection provided to the flight crew. The application does not include any changes in separation responsibility between ATC and flight crews. Although the application is cockpit-based, it is also expected to function at an airport where ATC has access to Airport Surveillance Detection Equipment version 3 (ASDE-3) and its associated Airport Movement Area Safety Systems (AMASS) as well as Airport Surveillance Detection Equipment X-band (ASDE-X). Unlike the AMASS reactive alerts however, the SMM could provide runway status information so that flight crews can predict a possible conflict. Flight crews may use the SMM as a supplemental aid to their out-the-window visual scan but not as the sole means of determining runway occupancy.

Flight crew use of the SMM, and the associated increase in situational awareness, may initially instigate some communications with ATC that might not have normally occurred. However, as flight crews become more familiar with the SMM, the interactions may decrease and the communications that continue to exist provide the safety benefit expected of the application. Additionally, flight crews and controllers may use flight identification when communicating about traffic callouts.

F.1.2.2 Procedures and Responsibilities

F.1.2.2.1 Air Traffic Control

The ATC positions that are involved in FAROA are the tower / local and ground controllers. Controller procedures and responsibilities are not expected to change significantly with the cockpit-based FAROA application. Initially, increased communications that might not have normally occurred may result due to flight crew use of the SMM and the associated increase in situational awareness. However, as flight crews become more familiar with the SMM, the interactions may decrease and the communications that continue to exist provide the safety benefit expected of the application. Additionally, if ATC surface surveillance with alerting is in use and the flight deck also has alerting4, there may be more interactions between flight crews and ATC. As with the addition of any new technology, the potential exists for ATC actions to change with the addition of the SMM on the flight deck. One change that is possible is the use of flight identification when pointing out traffic (see sections 1.2.3 & 1.4.3).

[4] If an alerting scheme is included with the ATC equipment, the cockpit alerting should be compatible with the ATC alerting so that issues do not arise stemming from different alerting schemes.

F.1.2.2.2 Flight crew

No changes in the basic responsibilities, including separation responsibility, of flight crews or air traffic controllers are required. The flight crew may use the SMM as a supplemental source of information to aid in the out-the-window visual scan. The SMM may be used by the flight crew during final approach and prior to takeoff or crossing a runway as a supplemental source of information to determine runway and final approach occupancy.

Efficient control of the displayed information must be assured to minimize increases in crew workload during critical phases of flight. During final approach and landing, automation of certain SMM features may be desirable to ensure that map scale and display clutter are managed in an efficient, timely manner. This will enable the crew to easily refer to the SMM to assess runway occupancy with enough time to coordinate with ATC or to make a decision to go-around if necessary.

Use of electronic surface map information and a display to support the FAROA application will require enhancements to flight deck operating procedures to effectively integrate the information with concurrent, normal cockpit tasks. For example, a confirmation of a runway being clear prior to crossing may become a formal procedure. A task analysis to a level of detail which identifies sequences of crew actions and the supporting information requirements should be used to guide the development of operating procedures and allocation of functions to crew or automation (See §F.3.1)

The operating procedures should be designed to distribute workload among crewmembers in a manner consistent with safe operating practices that ensure that one pilot is always in control of the aircraft. In all aircraft, but especially in single pilot aircraft, the map display must be designed to minimize diversion of attention from primary aircraft control, especially during critical phases of flight such as final approach and landing.

If alerting is implemented on the flight deck, flight crews will need to be provided guidance on the appropriate response to the alert. If an advisory type of alert is implemented, flight crews may be expected to perceive the alert and to look out-the-window for the potential conflict to determine the appropriate course of action. One potential issue with an advisory type alert is the possibility of an advisory occurring on short final with insufficient time for the flight crew to perform a visual scan. Without sufficient time, the flight crew may decide to execute a go-around, possibly unnecessarily. Such a possibility should be considered in the design of the equipment. Alerting requirements beyond an advisory level are TBD.

Flight crews will have to be trained on the fact that not all aircraft may be displayed on the CDTI either due to lack of equipage or inoperative equipment. These aircraft must be acquired visually only, as with current operations. The flight crew must continue to scan outside the window for all such traffic.

Since the flight crews do not normally see then entire airport surface and the traffic movement, they should be trained on current operations and what they should expect to see during daily operations. Without such training it is possible that go-arounds or rejected takeoffs could initially increase.

F.1.2.2.3 Airlines Operations Center & Flight Service Stations (if applicable)

The airlines operations center and flight service stations are not expected to be directly involved in this application.

F.1.2.3 Proposed New Phraseology

The use of current standard phraseology will be adequate for communicating traffic information. However, communications could involve the use of flight identification. For example, with a CDTI, the ATC taxi instruction could be: “XYZ 123, cleared to cross Runway 36. Traffic is holding for you on Runway 9.” It is yet to be determined if flight identification can be used with existing phraseology (see section F.1.4.3).

F.1.2.4 Aircraft Separation / Spacing Criteria

There is no change in aircraft separation minima for this application.

F.1.2.5 Sample Scenarios

This scenario describes runway related operations during a flight from and then return to airport KABC (see Figure F-2). The airspace around KABC is Class B and is active. The Part 121 aircraft is parked at the terminal building in the northwest corner of the field. The flight crew is departing from KABC with a landing at another airport then returning to KABC to complete the flight segment. The conditions are daylight with 10 miles of visibility and no precipitation. The sample scenario begins after the flight crew has received the weather, conducted other preflight duties, and has taken their positions in the aircraft which is parked at the terminal building.

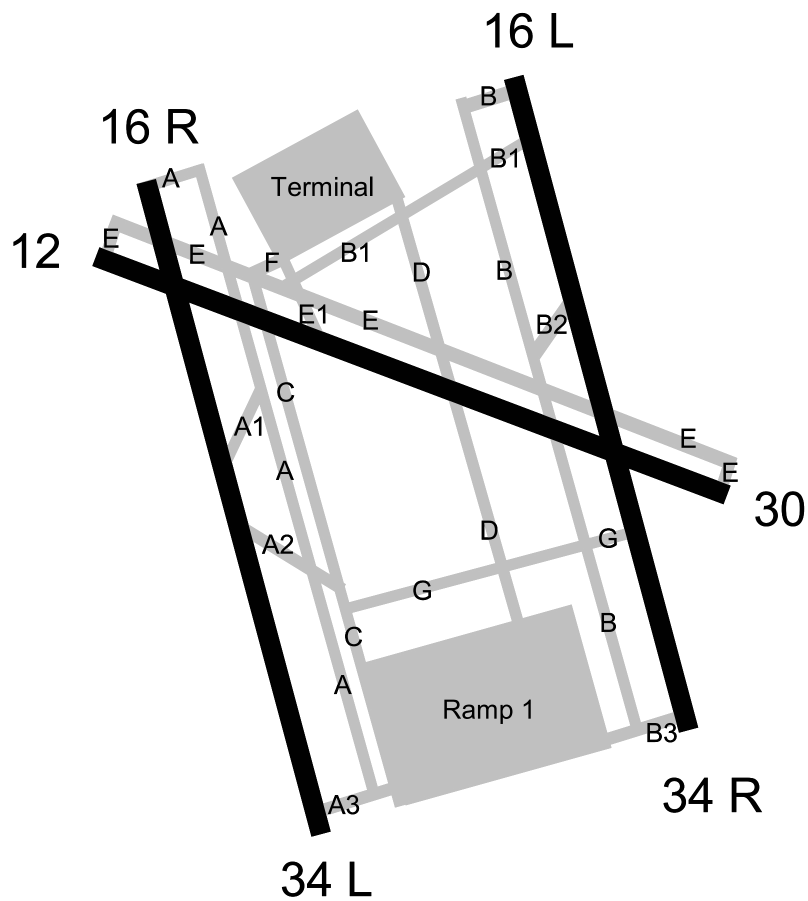


Figure F-2 **KABC Airport Layout.**

F.1.2.5.1 Preflight & Pushback

After starting the auxiliary power unit (APU), the flight crew selects the SMM of the KABC airport. The SMM display the actual surface map as well as traffic, including other aircraft and properly equipped airfield vehicles. The initialization procedures include confirming the currency of the map database as well as verifying ownship position. The SMM defaults to certain map configuration for taxi. The map features displayed in the default taxi configuration could include buildings, taxiways, taxiway labels, buildings, hold short lines, and runways. The flight crew decides to leave all the features displayed for taxi. The taxi procedures and use of the SMM that are not related to runway operations are described in the companion application description of Airport Surface Situational Awareness (ASSA).

Once the flight crew is released from the tug, they adjust the map display to an appropriate display range for taxi in the non-movement area. For example, the flight crew could select 0.5 nautical mile (nm) for the captain and 1.0 nm for the first officer. These ranges provide the captain with “local” / tactical information while the first officer operates on a longer range to view “global” / strategic information. Therefore, the captain who is taxiing the aircraft has the information of immediate concern and the first officer had information for the longer term.

Once the flight crew arrives at a designated holding position within the non movement area, they can contact ATC and receive their clearance: "<Flight number>, KABC Ground, taxi to runway 34 Left via Foxtrot, Echo, Alpha, and Alpha 3." After acknowledging the clearance, the flight crew can then enter the movement area and begin taxiing.

F.1.2.5.2 Runway Crossing During Taxi

As the flight crew is following the taxi instructions and joins Alpha, they observe both out the window and on the surface map that they will cross Runway 30. The hold short line is also depicted on the display. At this point, ground control advises them that they are cleared to cross Runway 30, and that traffic is holding in position. As a follow-up to this clearance, the flight crew checks the final approach path both out the window and on the SMM. It appears clear. The flight crew also observes the aircraft holding at the end of Runway 30, but they are not sure if it is moving. The first officer decides to turn on velocity vector lines for all aircraft. This allows them to see the velocity vector line of the aircraft holding on the runway. Since no velocity vector line is seen emanating from this aircraft, and it does not appear to be rolling, they decide to cross the runway. After crossing Runway 30 and continuing to taxi down Alpha, the flight crew sees the velocity vector line for the aircraft begin to lengthen as it starts its takeoff roll.

F.1.2.5.3 Takeoff

As the flight crew approaches the runway they observe the label for Runway 34 Left on the SMM, confirmed by the surface markings and signage visible out the window. The flight crew stops the aircraft at the hold short line for 34 Left. At this point the SMM is used to determine if the runway is clear for their takeoff. This task is performed by the PNF with a glance at the SMM to detect possible traffic conflicts. . In addition to setting these ranges, they deselect all surface features, except for the runways (e.g., they remove buildings, taxiway labels).

The flight crew contacts tower and receives a clearance, "<Flight number>, KABC Tower, taxi into position and hold Runway 34 Left." As they enter the runway the PNF selects center map mode. This allows the flight crew to monitor both the runway ahead for blundering aircraft as well as the final approach course as aircraft arrive for landing on their runway. No conflicts are evident on the SMM when the flight crew is cleared for takeoff. After takeoff, the flight crew can deselect SMM information, as desired.

F.1.2.5.4 Terminal Area Arrival and Landing

After the flight crew departed KABC, they flew to their destination and are now returning to the terminal area of KABC for their final landing of the trip. As they enter the terminal area, they choose the SMM function. The default information that appears when airborne on the SMM is runways only. Other features can be added as desired; however, at the current distance from the airport, any other surface information is likely not useful.

The flight crew is vectored onto the final approach course for the visual approach behind an aircraft (RSB 456), on final to Runway 34 Right. When on an extended final, the flight crew chooses the SMM range options of 10 miles for the PNF and a new feature called auto zoom for the PF. The auto zoom function is an option where the range adjustment of the SMM is automatically accomplished by the system. The zoom range level changes in approximately 0.1-mile increments with the runway environment remained at the top of the display as the aircraft flys a straight-in final. The visual effect is that the runway grows larger as the display range is automatically adjusted downward as the aircraft approaches the runway. This feature allows the flight crew to have the benefit of continuous view of the runway environment without having to manually select shorter ranges while on short final, a high workload phase of flight.

Since the flight crew is also interested in information on the aircraft it is following (RSB 456) they select the aircraft on the SMM. The selection of that aircraft displays an information data block which includes range to target, weight category, ground speed, and call sign

Once the ownship aircraft is aligned in trail of RSB 456 closure rate information is automatically displayed. As the crew continues the approach behind RSB 456, the crew monitors the display to detect unusual decelerations by RSB 456. Touchdown is verified by the change in target color from green to brown. After RSB 456 touches down and rolls down the runway, the flight crew notices on the SMM that the RSB 456 ground speed is very high when it is at Alpha 2 and that it will not make the Alpha 1 turn off. Therefore, it most likely will have to roll to the end of the runway. With this in mind, the flight crew decides to adjust their final approach speed to a minor degree to allow more time for RSB 456 to clear the runway.

As the flight crew continues to approach the runway, they elect to use the velocity vector feature to determine aircraft acceleration and deceleration. They observe an aircraft taxiing down Alpha and turning onto Alpha 3. They notice that the velocity vector line for this aircraft is shortening indicating that it is slowing to hold short. At the same time they notice that, according to the map display, RSB 456 has cleared their runway at Alpha. The crew also visually verifies that the runway is clear before landing. The flight crew has received a landing clearance from ATC and the runway now appears clear. The flight crew continues to a normal landing. Upon landing, additional surface map information automatically appears such as taxiways and taxiway labels that provide additional information to assist in the taxi to the terminal building.

F.1.3 Requirements

F.1.3.1 Display & Interface / Functional

Surface display functions are list in Table F-1 (for all potential features see Table ???). Those labeled as "**Required**" in the necessity column are believed to be needed to perform the FAROA application. Those labeled as "Desirable" are not required to perform the procedure but would increase the utility of the operation. See the text following the table for a further description of the function and its associated need.

Table F-1 FAROA Display Requirements

Display Elements	Display Range Reference	R
	Range Options / Zoom	R
	Reduced Display Range[1]	R[2]
	Track Up / Heading Up / Course Up Map Mode	D
	Surface Moving Map Database	R
	Target Selection	D[3]
Symbols	Own-Ship	R[4]
	Traffic	R
	Selected Target	D[3]
Traffic Elements	2D Positioning Information	R
	Identification[5]	D
	Horizontal Velocity Vector[5]	D
	Heading[6]	R
	Traffic On-Ground / In-Air / Unknown Status	R
Selected Traffic Elements	Highlighting	D[3]
	Identification	D[3]
	Category	
	Ground Speed	D[3]
	Range	D[3]
	Closure Rate	D[3]

R = Required
D= Desirable

Notes:

1. *Display ranges smaller than those currently available on production navigation displays.*

2. *For example, ½ or 1 mile range.*

3. *If these features are available for airborne applications, they should be available for ground application also.*

4. *Required if the display is referenced to ownship. However, a implementation that is north up and an inset (e.g., "picture in picture") may not require ownship.*

5. *If required, should be available for display but not necessarily continually displayed.*

6. *Or other information that can be used for the vehicle symbology to show directionality.*

The base display for the FAROA application will include the depiction of traffic and the runway environment but will not include any form of cockpit alerting. The base display may require flight crew action to choose the display of surface information.

F.1.3.1.1 Required Functions

1. Ability to determine ownship position

   The display of ownship would be required on a display that was ownship referenced. An indication of ownship position is necessary so that the flight crew is able to orient himself or herself based on ownship position. This could be done via the use of an own aircraft symbol, as is done with CDTIs and navigation displays. Own aircraft symbol may not be a required feature since one possible implementation could have a "picture-in-picture" or pop-up display that would show the airport runway environment regardless of ownship position. For example, if the flight crew were on a 3-mile final and wanted to view the entire airport including crossing runways, a display option could be to show a "quick view" of the entire airport without displaying ownship, since it would be off the scale required to show the entire airport. However, a symbol representing ownship position but also indicating its off-scale location would be a better implementation.

2. Ability to determine traffic on-ground / in-air / unknown status (Traffic On-Ground / In-Air / Unknown Status)

   This function is required so that the flight crew is able to make the determination of whether an aircraft is airborne or on the surface and whether it must be monitored for runway occupancy.

3. Ability to determine traffic position (Traffic symbol, traffic 2D positioning information, surface moving map database, traffic heading)

   Traffic position is required if the flight crew must make the determination if an aircraft is on or near the runway or on final approach. Traffic position could be shown on the display by positioning an aircraft symbol at the appropriate location.

4. Ability to access the runway environment with minimal number of actions

   The surface display must be accessible and changeable with a minimum number of actions since the displayed information is needed during a period of high workload (FAA, 2001).

   An auto-zoom function may reduce flight crew workload; however, some issues should be considered when considering auto-zoom. This feature could be undesirable since the designer must assume what the flight crew's informational needs are and when the flight crew needs them. While an auto-zoom could be a selectable feature, it should not be the only option available to the flight crew.

   Another issue that needs to be addressed prior to design is the layering of the surface display information. In other words, should all of the runway environment information be displayed with one button push or should options exist to the amount of information to be shown. The more options, the more interaction required.

5. Ability to determine runway or final approach status (Reduced display range)

Since this application involves helping the flight crew to determine whether an aircraft is on or off the runway or on final approach, the display must provide accurate traffic position and runway layout information. The display must also include a smaller display scale option than those seen in some current cockpit navigation displays (i.e., less than 10 or 5 miles).

6. Ability to select several display range options / zoom (Range options / zoom)

This could be either a function that allows the flight crew to manually zoom the display or an autozoom implementation. Such a feature is necessary for the flight crew when attempting to determine runway or final approach occupancy when ownship is both on the surface and on final approach.

Depiction of runway environment: The minimum element of the runway environment to be displayed for FAROA is the ownship runway. However, the runway environment could include taxiways near the runway, runway edge lines, hold short lines, etc. Ownship runway is desired to be the minimum since current navigation displays depict the ownship runway with the information from the FMS navigation database. The runway information depicted may include enough information on the runway to depict its orientation but not the true length or width.

North-up / track-up / course up: The preferred map orientation is track, heading, or course up. A north-up map may be an option for planning purposes or could be a low-cost implementation.

The display shall show ownship position and all received traffic vehicle positions that appear within the display field of regard that satisfy the normal or degraded display performance criteria. Vehicle position symbology shall correspond to the underlying aerodrome map that also shall be displayed if the aerodrome database is determined to be valid. Ownship and traffic vehicle symbology shall be clearly discernable from aerodrome map features. For all surface and airborne vehicles for which valid ground track or heading information is available and meets the performance requirements, the vehicle symbology shall be directional to indicate the ground track or heading of the vehicles.

F.1.3.1.2 Desirable Functions

1. Ability to determine traffic velocity (0 versus. movement) (Horizontal velocity vector)

The flight crew may need to be able to determine whether an aircraft is accelerating, decelerating, or not moving. This will be important for determinations of other aircraft intent, e.g., an aircraft accelerating and crossing over the hold short line is encroaching on the runway. One potential display feature that could meet this need would be a traffic horizontal velocity vector. However, a horizontal velocity vector is not a required feature for the base implementation where the flight crew is required to determine runway occupancy. The horizontal velocity vector may be a required feature for future builds where the flight crew is required to make judgements and / or predictions of potential occupancy and conflicts when on final approach.

2. Ability to uniquely identify traffic

If flight crews are able to uniquely identify traffic, e.g., via traffic identification, ATC will be able to use traffic identification when pointing out traffic to flight crews. Use of traffic identification should overcome some of the ambiguity with identifying specific aircraft. The display of traffic category for the flight crew could also aid in the locating and differentiating of traffic.

3. Ability to select a particular target

The ability to select and highlight a target could provide the flight crew with additional information on the selected aircraft from which the flight crew could better monitor closure between the aircraft. Additionally, highlighting a target provides a visual cue in regards to one specific aircraft of interest. The selection feature could also provide aircraft identification for one specific aircraft without cluttering the display with all aircraft identification.

4. Ability to determine selected target velocity information

Additional information on a selected target such as closure rate and ground speed may provide the flight crew with the information necessary to determine if an aircraft is accelerating, decelerating or not moving.

F.1.3.1.3 Optional Functions

1. Ability to pan the display

A pan feature may be needed so that flight crews are able to view areas of the surface in more detail than is possible with an aircraft centered view.

Clutter of a surface display was identified as an issue during use of surface maps at an operational evaluation (FAA, 2001). Specifically, the issue was the display of numerous ground target and the associated clutter. Options for the reduction of clutter include: reducing aircraft symbol size, selectively removing aircraft that are determined to be a non-issue, and the de-emphasizing (e.g., dimming) of aircraft that are non-issues. The first and last options are a preferred method so that the flight crews can make their own determination as to whether aircraft are of concern and to minimize marginal targets appearing and disappearing from the display. An option for decluttering when the display range is at a greater distance is not displaying traffic until the surface / runway environment information became more usable at closer display ranges. If alerting is not implemented, consideration should be given to displaying traffic as soon as possible so that the flight crew is able to make judgements on conflicts. Regardless, the surface display should support the visual determination of runway occupancy.

The flight crew will desire to use the display when on final or on the airport surface. When ownship is on final, a conflict exists between the proper display range for both viewing the entire runway and determining if an aircraft is on a runway or just holding short. Some display options could include an airport-centered inset, i.e., “picture in picture”, that would depict the entire runway environment (including crossing runways) at an appropriate range. This could also be achieved by using the same information that would be displayed on the inset as a separate map that would be displayed over the airborne navigation information for a flight crew selected period of time. Future builds could include a perspective display that would alleviate these issues.

Degraded information shall be displayed and identified as degraded. Degraded information for traffic or ownship vehicles shall be clearly discernable on the display from non-degraded information (e.g., use different color and a redundant means other than color).

The FAROA application shall not artificially adjust vehicle positions. This requirement is meant to preclude "snapping" the vehicle positions artificially to be on aerodrome surfaces intended for vehicle movements. An example of artificial position adjustment includes snapping the displayed vehicle position to be on a taxiway or runway rather than on the grass between them. Artificially adjusting reported vehicle position increases the risk of providing misleading information to the flight crew.

F.1.3.2 Infrastructure Requirements

F.1.3.2.1 Ground ATC

Depending on the input source to the CDTI, some ground infrastructure may be required. A CDTI that relies upon ADS-B will not require any ground infrastructure for this application; however, one that relies upon TIS or TIS-B information will require ground stations for the up-link of traffic information. Several ground systems for TIS (i.e., equipped Mode S sensors) are already in place and additional systems are being implemented.

For this application, ATC may not need to have knowledge that the aircraft is CDTI equipped.

F.1.3.2.2 Flight Deck

The equipment needed on the aircraft will include the display, the associated processing systems, and a SMM database.

F.1.3.2.3 Airlines Operations Center & Flight Service Stations (if applicable)

No additional equipment is expected to be needed by either the airlines operations center or the flight service stations.

F.1.4 Other Considerations

F.1.4.1 Relationship to other programs and future enhancements

Other related programs:

- Airport Surveillance Detection Equipment version 3 (ASDE-3) and its associated Airport Movement Area Safety Systems (AMASS)
- Airport Surveillance Detection Equipment X-band (ASDE-X)
- SF21 Ohio River Valley and Capstone projects
- NASA Runway Incursion Prevention System (RIPS) & Synthetic vision

- Airport Surface Situational Awareness application
- FAA Technical Center laser research
- Flashing Precision Approach Path Indicator (PAPI) research being conducted at Long Beach, CA

F.1.4.2 Training requirements

Training is a major implementation issue for both general aviation and commercial pilots. A few issues that must be addressed in training include over-reliance on the equipment to the detriment of an out-the-window scan, head-down time, additional workload of mapping the CDTI image onto the visual image, and a mixed equipage environment. The FAA may need to provide standards (e.g., Advisory Circulars) for such training. Unique implementation issues especially for single pilot operations will need to be addressed. Additional training for ATC may also be needed.

F.1.4.3 Other Issues

F.1.4.3.1 Issue: Display of Surface Map on Navigation Display in "Glass" Cockpits

While flying an instrument approach, what is the required (if any) information to have displayed on the navigation display? If some aircraft operations require raw data to be displayed on the navigation display while flying the approach, the surface map cannot be displayed so that the flight crews can check the final approach and runway.

Priority:
Resolution Method:
Status: Closed
Resolution: It appears to be that aircraft operations that require raw data monitoring on the navigation display only require that information on one of the pilot's navigation display. The raw data could also be monitored on a RMI. If the approach is either an Instrument Landing System (ILS) or Area Navigation (RNAV) approach, the Primary Flight Display (PFD) course deviation indicators can be used and the information displayed on the navigation display is the pilot's option.

F.1.4.3.2 Issue: Position Accuracy

There are demanding requirements on ADS-B position reports (e.g., accuracy) in surface applications. Whereas GPS is the likely source of position data for ADS-B on the surface, meeting the accuracy requirements for this application may require the Wide Area Augmentation System or the Local Area Augmentation System (WAAS or LAAS).

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.3 Issue: RF Propagation Anomalies

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.4 Issue: Shorter Display Range Required

The traffic and runway depictions will require operation with a display scale much finer, i.e., less than 10 miles, than those seen in some current flight decks for airborne operations.

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.5 Issue: Flight Crew Ability to View Desired Area on the Runway Display

A conflict exists between viewing a small enough range to determine if an aircraft is on the runway versus viewing the entire runway area…

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.6 Issue: Use of flight identification

Currently, flight identification is not used by ATC. The air traffic control handbook (FAA Order 7110.65) may have to be modified to allow for the reduction in the current phraseology. The use of flight identification for traffic call outs as an addition to current communications is neither currently allowed or prohibited. Therefore, a change to FAA Order 7110.65 may be necessary to clarify and allow for the use of flight identification.

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.7 Issue: Flight Crew Over-Reliance on the Equipment to the Detriment of an Out-the-Window Scan

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.8 Issue: Flight Crew Head-Down Time

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.9 Issue: Flight Crew Workload of Mapping the CDTI Image onto the Out-the-Window Visual Scene

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.10 Issue: Mixed Equipage Environment

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.11 Issue: Layering of the Surface Display Information

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.12 Issue: Clutter of the Surface Display

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.13 Issue: Alerted Without Aircraft on Runway in Sight

If a form of alerting is implemented that alerts the flight crew of an occupied runway, what are the flight crew actions? If the flight crew receives the "runway occupied" alert, doesn't see the aircraft, and lands based on that fact that the aircraft was not seen visually, what are the repercussions?

Priority:
Resolution Method:
Status:
Resolution: This issue could be compared to the procedure approved by some airlines which allows the flight crew to disregard a Traffic alert and Collision Avoidance System (TCAS) Resolution Advisory (RA) if he has better information.

F.1.4.3.14 Issue: Location of Surface Display in the Cockpit

Is there a required location for the surface display in the cockpit, e.g., forward or secondary field of view? Will this requirement be closely related to the level of alerting?

Priority:
Resolution Method:
Status:
Resolution:

F.1.4.3.15 Issue: Do WAAS and LAAS Work on the Airport?

Issue not as much do you need WAAS or LAAS to operate on the surface but is it useable on the surface.

Priority:
Resolution Method:
Status:
Resolution:

F.2 Requirements Analysis for Final Approach and Runway Occupancy Awareness (FAROA)

F.2.1 Introduction

Working from the FAROA application description contained in Section F.1, this section contains the safety and performance analyses used to derive the FAROA application requirements. As described in the application description, the FAROA application includes both an ownship positional awareness function and a traffic situational awareness function that are applicable when the ownship aircraft is on or near a runway. The requirements for surface applications within the same applicable domain that only provide the ownship positional awareness function may be different from those defined for the FAROA application.

F.2.1.1 Relationship to ASSA

The FAROA application is a subset of the Airport Surface Situational Awareness (ASSA) application. Both applications have been established to increase surface situational awareness of vehicles on the surface or vehicles soon to be on the surface (e.g., on the final stages of an approach).

The FAROA application at a minimum is required to have a valid database that contains all the runways at the airport. The ASSA application at a minimum is required to have a valid database containing all the runways and taxiways in the airport "maneuvering area" as defined in ICAO Annex 14 [ref. 3, section 1].

It is permissible to equip with the FAROA application and not the ASSA application. However, if one equips with the ASSA application, it includes the FAROA application. The rationale is that it is operationally acceptable for surface situational awareness to cover only near runways (e.g., when just a runway map database is available that does not include taxiways). However, it is not acceptable to cover only taxiways without also covering runways (e.g., if taxiways are provided in the database, runways must also be provided).

Analogous to ASSA, the FAROA application includes ownship and traffic awareness functions. The FAROA application is potentially active when the ownship is on a runway, *near a runway* [see note below] when on the ground, and near a runway on the final stages of an approach. FAROA is required to have the capability to indicate all traffic targets that are on or near a runway, and it may provide traffic targets that are not "near" the runway (e.g., surface traffic on taxiways).

<u>Note:</u> *For the FAROA application, "near a runway" refers to locations that include a) on the ground within 100 meters of the runway, and b) airborne within 3 NM of the runway and below 1000 feet height above the airport surface. The airborne region has been established to encompass traffic on the final stages of approach or initial stages of departure.*

F.2.1.2 Application Assumptions

Prior to presenting the specific analyses, relevant FAROA application assumptions are described in the following paragraphs. These assumptions include a) the personnel using the application and vehicle for which the application analyses were based, b) the set of information presented to those personnel, c) the intended use of the information, and d) the environmental use assumptions.

F.2.1.3 Personnel Using and Vehicle Assumptions

The FAROA application analyses assumed that the only personnel using the FAROA information were trained operators in suitably equipped airport vehicles. Airport vehicles include aircraft, and they may also include other surface vehicles (e.g., snowplows, emergency vehicles, tugs, follow-me vehicles, baggage vehicles, fuel trucks, catering trucks, etc.). For analysis simplicity, the only vehicle operator tasks specifically considered were for aircraft flight crews, as the operational scenarios associated with other surface vehicle operators were not specifically addressed.

Note: *The FAROA application analyses contained herein do not consider the use of FAROA displays by the air traffic/ground controllers (ATC).*

F.2.1.4 Information Set Assumptions

It is assumed that the set of information provided by the FAROA application is consolidated on one display that contains an indication of ownship vehicle position and the positions of participating traffic vehicles, relative to an underlying map, which contains at least the runways. It is also assumed that all vehicle positions shown on the display are projected to the same point in time. The vehicle positions include vehicles on the airport surface as well as aircraft on the final stages of approach and the initial stages of departure. The analysis further assumes that traffic vehicle reports are assessed for satisfying one of three defined levels of performance, two of which are displayed to the operator. These levels of performance include:

1. Good performance (meets the “minimum” requirements for “normal” performance),

2. Degraded performance (traffic report data has degraded to the point where there is a higher level of uncertainly in vehicle positions, but the uncertainty still meets the level required for “degraded” performance which is expected to provide reasonable situational awareness information), and

3. Insufficient performance (information is too poor such that the traffic position symbol typically must be removed from the display).

The analyses did not consider the inclusion of any alerting functions associated with the FAROA application.

Note: *Potential enhancements to the FAROA application, such as a runway incursion alerting function, were not considered in this application analysis. An alerting function may include, for example, appropriate algorithms and displays that alert the flight crew of a potential runway occupancy hazard. Such an application that includes a runway alerting functions will have different (e.g., typically more demanding) requirements than those specified herein for the FAROA application.*

F.2.1.5 Operational Use Assumptions

It is assumed that vehicle operators will only use the FAROA application information to increase awareness of ownship and traffic positions. This awareness will supplement the operator's normal safe procedures (e.g., supplement the operator's out-the-window visual assessment of ownship, traffic, and obstacles including, if applicable, air traffic runway control). The FAROA application may be approved and used at both air traffic controlled airports as well as at non-towered airports.

The FAROA CDTI display will not be used to provide any guidance information, but it may assist the vehicle operator in assessing runway occupancy. This assessment may influence the vehicle operator in making decisions in accordance with safe movement procedures. The operator is assumed to be ever vigilant for traffic whose information does not appear on his FAROA CDTI because of non-participating aircraft or equipment failures.

F.2.1.6 Environmental Use Assumptions

It is assumed that the FAROA application may be used by the operator of any vehicle that is on or near a runway where the application is supported with the appropriate information including a runway map database.

The FAROA application is assumed to be capable of operating during all conditions when runway movements are conducted (e.g., during all visibility conditions from very good visibility to poor visibility – Visibility Conditions 1 though 4 as defined by ICAO). It is assumed that safe operating procedures are in place that do not rely on FAROA. The FAROA application augments the existing safe operations by providing supplementary information on the CDTI that may aid the vehicle operator in assessing ownship and traffic runway occupancy to support conducting safe operations. This additional information is expected to provide an additional margin of safety and perhaps efficiency.

F.2.1.7 Transition Paragraph

The FAROA application analysis begins with an identification of the phases, processes, and roles associated with runway movement operations. The phases, processes, and roles have been identified to aid the thorough consideration of the FAROA application safety and performance analyses. Section F.2.3 contains three safety analyses including: 1) hazards and potential operational consequences for FAROA, 2) failure modes and affects analysis (FMEA) for the FAROA CDTI display, and 3) fault tree analysis for the operational hazards associated with runway movements using the FAROA application. Based upon these safety analyses and consideration of the most demanding operational scenarios for the FAROA application, the performance requirements have been established based upon the rationale described in Section F.2.4. Section F.2.5 summarizes the performance requirements for an FAROA system in an easy to reference table and includes a list of high-level functional requirements.

F.2.2 Phases, Processes, and Roles for Runway Operations

Operations associated with runway occupancy can be grouped into five distinct phases. These phases include:

- P1. Setup
- P2. Crossing Runway
- P3. Takeoff
- P4. En route Decent and Initial Approach
- P5. Final Stages of Approach and Landing

These phases are illustrated in Figure F-3 The phases in this figure are further subdivided into "processes" or tasks associated with the flight crew or air traffic controllers (ATC) that are conducted during each operational phase. For airports that do not have controllers, the flight crew role expands to become solely responsible for conducting safe operations in and around the runways.

Operations using FAROA do not necessarily progress through all five phases. For example, crossing a runway involves only phases 1 and 2, takeoff involves phases 1 and 3, and approach and landing involves phases 1, 4, and 5.

Figure F-4 identifies the additional flight crew tasks (i.e., processes) associated with FAROA during the five phases associated with the use of the FAROA application. It is this set of processes that are analyzed further for potential operational hazards associated with using FAROA to support runway operations including crossing a runway, takeoff, and landing (see Section F.2.3.1).

FAROA Operational Notes:
1. There are no new ATC Roles associated with the Flight Crew using the FAROA application.
2. The responsibilities of ATC and the Flight Crew are not changed when the FAROA application is used.
3. The Flight Crew may use FAROA to supplement traffic and ownship situational awareness during operations where runway occupancy is an issue (e.g., crossing runway during taxi, takeoff, and final approach & landing).
4. To assess the traffic situation for potential runway occupancy conflicts, the Flight Crew may use a combination of information from several sources including visual, ATC commands and advisories, FAROA, ATC party line communications, alerting systems, etc.

P1. Setup	ATC Role: None	Flight Crew Role: 1. Perform system checks and verify FAROA system/CDTI is correctly functioning.
P2. Crossing Runway (Taxi)	ATC Role: 1. Monitor Traffic 2. Provide Taxi Clearance / Instructions 3. Provide Traffic Advisories/Safety Alerts 4. Ensure Flight Crew Acknowledges/Readbacks (as appropriate) issued clearances, info. assignments, or instructions 5. If No Flight Crew Acknowledge or Incorrect Readback confirmation, re-issue.	Flight Crew Role: 1. Identify and Stop at Stop Point. Report position to ATC. 2. Adjust CDTI for Taxi Across Runway FAROA Task. 3. Request/receive runway crossing clearance and/or instructions from ATC. Respond to ATC as to whether or not ownship will comply. 4. Idenfity / Monitor / Assess traffic situation prior to crossing runway.
P3. Takeoff	ATC Role: 1. Monitor Traffic 2. Provide Takeoff Clearances/Info./Instructions 3. Provide Traffic Advisories/Safety Alerts 4. Ensure Flight Crew Acknowledges/Readbacks (as appropriate) issued clearances, info., assignments, or instructions 5. If No Flight Crew Acknowledge or Incorrect Readback confirmation, re-issue.	Flight Crew Role: 1. Identify and Stop at Stop Point. Report position to ATC. 2. Adjust CDTI Display for FAROA Takeoff Task 3. Request/receive takeoff clearance and/or instructions from ATC. Respond to ATC as to whether or not ownship will comply. 4. Identify / Monitor / Assess traffic situation prior to entering and while on takeoff runway.
P4. En Route Decent & Initial Approach	ATC Role: 1. Monitor Traffic 2. Clear aircraft for approach 3. Assess traffic for potential conflicts 4. Provide Traffic Advisories/Safety Alerts/ instructions to resolve potential traffic conflicts	Flight Crew Role: 1. Retrieve Taxi Chart (Paper or Electronic) 2. Request/receive approach clearance from ATC. Respond to ATC as to whether or not ownship will comply. 3. Plan Exit Taxiway and Taxi Route 4. Adjust CDTI for Decent and Initial Approach FAROA Task 5. Identify / Monitor / Assess Traffic Situation for possible conflict
P5. Final Stages of Approach and Landing	ATC Role: 1. Monitor Traffic 2. Assess traffic for potential conflicts 3. Provide alerts/instructions to resolve potential traffic conflicts	Flight Crew Role: 1. Adjust CDTI for Final Approach/Landing FAROA Task (e.g., Range, information) 2. Identify / Monitor / Assess Traffic Situation for possible conflict during final stages of approach and landing.

Figure F-3 Operational Phases, Processes, and Roles for Tasks Associated with the FAROA Application

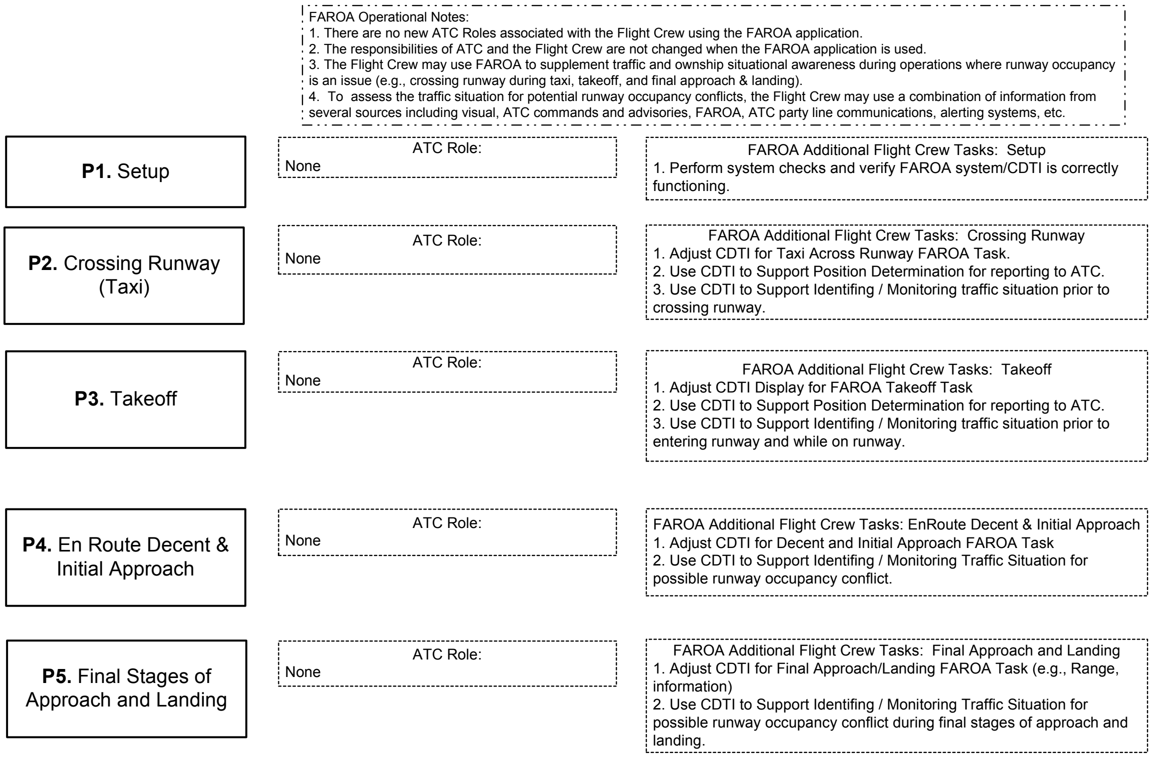


Figure F-4 New Tasks Associated with FAROA

F.2.3 Hazard and Safety Analysis

F.2.3.1 FAROA Hazards and Potential Operational Consequences Analysis

The hazard analysis for FAROA was conducted by careful examination of the phase and process diagrams illustrated in Figure F-4 above. The section below provides an overview of the analysis, followed by a section that contains a detailed hazards and potential consequences safety, Table F-2.

F.2.3.1.1 Overview By Phases

F.2.3.1.1.1 Phase 1: Setup

During the setup phase, the flight crew performs FAROA system checks, as necessary, to verify the correct functioning of the system. Undetected failures have the potential to cause hazards when the equipment is used to support the operational phases 2 through 5.

F.2.3.1.1.2 Phase 2: Crossing Runways

The crossing runways phase of the FAROA operation occurs during a taxi operation, when flight crew is required to cross a runway to get to his destination. Crossing runways involves the flight crew following the appropriate surface movement procedure. Typically, this procedure involves stopping short of the runway, requesting and obtaining the appropriate clearance to cross the runway (at ATC controlled airports), assessing the traffic situation, and moving the ownship vehicle across the runway when the traffic condition permits. The FAROA application may be used to help the flight crew identify potential runway occupancy traffic conflicts.

F.2.3.1.1.3 Phase 3: Takeoff

The takeoff phase of the FAROA operation occurs after taxiing to the appropriate end of the departure runway. The flight crew must follow the appropriate takeoff procedure.

At ATC-controlled airports, this procedure typically involves stopping short of the takeoff runway, requesting and obtaining clearance to move the aircraft into takeoff position, continually assessing the traffic/runway occupancy conditions, moving into takeoff position when the traffic condition permits, obtaining clearance to takeoff, and beginning takeoff roll when the traffic condition permits.

At non-ATC controlled airports, the procedure is essentially the same as that described above except there are no controllers managing the runway occupancy. The task of runway occupancy management becomes part of the flight crew's responsibility. After taxiing and holding short of the takeoff runway, the flight crew must assess the traffic/runway occupancy conditions. When the traffic condition permits, the flight crew announces their intentions to takeoff. They continually assess the traffic/runway occupancy conditions while moving into takeoff position and ultimately taking off.

The role of the FAROA application is the same, whether at ATC or non-ATC airports. The FAROA application may be used to help the flight crew identify potential runway occupancy conflicts.

F.2.3.1.1.4 Phase 4: En route Decent and Initial Approach

The en route decent and initial approach phase of the FAROA application occurs as its name implies during the decent and initial approach to an airport. The flight crew configures the FAROA application to support the approach and landing operation (e.g., adjusts the zoom level). The flight crew may use the CDTI as a supplemental means to start assessing runway occupancy conditions.

F.2.3.1.1.5 Phase 5: Final Stages of Approach and Landing

The final stages of approach and landing phase of the FAROA application occurs as its name implies during the final stages of an approach and landing, which also includes rollout and exiting the landing runway. The flight crew may use the FAROA information to help assess runway occupancy conditions.

F.2.3.1.2 Detailed Hazard and Consequences Analysis

As stated previously, the hazard analysis and potential consequences analysis for FAROA was conducted by careful examination of the phase and process diagrams illustrated in Figure F-4. Hazards have been identified for each process and depicted in Table F-2 by posing two hypotheses:

1. The process does not complete normally, and

2. The process completes based on erroneous information or assumptions.

These two hypotheses form the basis of the hazard/potential consequence analyses that are presented in Table F-2. Each hazard is identified with a unique number relating to the phase and process to enable reference.

The column in the table labeled "potential operational consequences" lists some of the important potential consequences of each hazard. These potential operational consequences include:

1. Surface collision

2. Leaving prepared surface

3. Erroneous maneuvers

4. Increased work load (confusion/distraction)

Note: *The "erroneous maneuvers" operational consequence encompasses a set of errors where the flight crew inadvertently maneuvers their aircraft. Such errors induced by FAROA may potentially include, for example, an inadvertent go-around during the final stages of approach because a fictitious traffic target appears to be occupying the runway.*

A consequence of a hazard is not necessarily immediate; the series of failures and combinations of hazards that potentially allow a hazard to result in a consequence are identified through a fault tree analysis that is documented in Section F.1.1.1.

The column labeled "FAROA Contributory Causes" lists some possible causes of the hazard. The list is provided for illustrative purposes and is not exhaustive; again, the fault-tree analysis that is provided in Section F.1.1.1 derives the potential causes of the relevant hazards in detail. The causes listed in the figure are useful to identify those hazards that require further analysis in terms of FAROA and its supporting subsystems.

The column labeled "Typical Avoidances" lists some factors that may help to reduce the probability of the hazard occurring. Again, this column represents a summary and is not an exhaustive list. Avoidances are more rigorously developed through the fault-tree process for the applicable hazards.

The column labeled "Mitigations" lists some factors that help to reduce the probability of the potential consequences once the hazard has occurred. Again, this column represents summary information and the mitigations are developed in detail in the appropriate fault-tree analyses.

The column labeled "Hazard Class" (for Hazard Classification) classifies the FAROA application hazards according to their operational severity. The notation for hazard classification is defined in Appendix AA.

Table F-2 Operational Hazards and Potential Consequences Analysis for FAROA

Table Nomenclature: P = Phase, ATC = Controller (Ground / Ramp), FC = Flight Crew, H = Hazard

Phase	Process	Hazards (FAROA Related)	Possible Operational Consequences	Contributory FAROA Causes	Typical Avoidances	Mitigations	Hazard Class
P1. Setup	P1.ATC: [All processes]	Identical to current procedures.					N/A
	P1.FC1: Perform FAROA System Checks to verify FAROA/ CDIT is correctly functioning	P1.FC1.H1: Loss of Function for FAROA equipment *[The FAROA system tests detect a failure, or a failure is obvious to the Flight Crew.]*	> Increased flight crew workload during setup. *(Flight crew will likely try several times to get FAROA system working before using current procedures only)* > Distraction	Detected FAROA Equipment Failure or Maintenance Failure (e.g., failure to keep database current)	Highly reliable equipment and proper maintenance.	Operational procedures	5
				Erroneously detected FAROA Equipment Failure or Maintenance Failure	Properly designed equipment built-in test and proper maintenance.	Operational procedures	
		P1.FC1.H2: Incorrect functioning of FAROA equipment *[The FAROA system tests do not detect an existing failure, such that the Flight Crew is given a false sense of trust in the FAROA system.]*	> Surface collision > Erroneous maneuver > Increased work load *(Misleading info. used in another phase of operation may lead to operational consequence)*	FAROA Random Failure	Built-in test, reliability, equipment redundancy	Operational procedures. Flight crew cross check with other redundant info. (e.g., visual, ATC commands and advisories, paper maps, mental model).	4 [Note 2]
				FAROA Design Fault	Equipment Requirements / Design Assurance and Certification Process		
				Improper FAROA Maintenance	Maintenance Procedures		
				Incorrect FAROA Database - wrong data - data handling	Database Development/ Testing/ Approval Procedures		

Table F-2 Operational Hazards and Potential Consequences Analysis for FAROA (continued)

Phase	Process	Hazards (FAROA Related)	Possible Operational Consequences	Contributory FAROA Causes	Typical Avoidances	Mitigations	Hazard Class
P2. Crossing Runway	P2.ATC: [All processes]	Identical to current procedures.					N/A
	P2.FC1: Adjust CDTI to support Taxi Across Runway Task.	P2.FC1.H1: Flight Crew has non-optimum presentation format for performing task	None.	Flight Crew does not select optimum mode for FAROA	Flight Crew training.	Operational procedures.	5
	P2.FC2: Use FAROA CDTI to support position determination for reporting to ATC	P2.FC2.H1: Incorrect ownship position reported to the controller.	> Surface collision > Increased work load (for both pilot and controller)	FAROA Random Failure	*See typical avoidances on row P1.FC1.H2*	Operational Procedures. Flight Crew cross check with other redundant info. (e.g., visual, paper maps, mental model). Controller cross check with visual or other information.	4
				FAROA Design Fault			
				Improper FAROA Maintenance			
				Incorrect FAROA Database			
				Flight Crew error reading CDTI thereby obtaining an incorrect position.	> Crew training > Good human factors design	Operational procedures and Flight Crew cross check with other redundant info. (e.g., visual).	
	P2.FC3: Use CDTI to support Identifying/ Monitoring Traffic	P2.FC3.H1: Traffic missing (Not all relevant traffic shown on CDTI)	> Surface collision > Increased work load	FAROA Random Failure	*See typical avoidances on row P1.FC1.H2*	Operational procedures and Flight Crew cross check with other redundant info. (e.g., visual).	4 [Note 1]
				FAROA Design Fault			
				Improper FAROA Maintenance			
		P2.FC3.H2: Traffic state information incorrect (e.g., incorrect traffic position)	> Surface collision > Erroneous maneuver > Increased work load	FAROA Random Failure	*See typical avoidances on row P1.FC1.H2*	Operational procedures and Flight Crew cross check with other redundant info. (e.g., visual).	4
				FAROA Design Fault			
		P2.FC3.H3: Traffic Misidentified	> Erroneous maneuver > Increased work load	FAROA Random Failure	*See typical avoidances on row P1.FC1.H2*	Operational procedures and Flight Crew cross check with other redundant info. (e.g., visual).	4
				FAROA Design Fault			
				Flight Crew error reading CDTI			
		P2.FC3.H4: Non-existent traffic targets displayed	> Erroneous maneuver > Increased work load	FAROA Random Failure	*See typical avoidances on row P1.FC1.H2*	Operational procedures and Flight Crew cross check with other redundant info. (e.g., visual).	4
				FAROA Design Fault			
		P2.FC3.H5: Relative traffic position incorrect	> Surface collision > Erroneous maneuver > Increased work load	FAROA Random Failure	*See typical avoidances on row P1.FC1.H2*	Operational procedures and Flight Crew cross check	4
				FAROA Design Fault			

Table F-2 Operational Hazards and Potential Consequences Analysis for FAROA (continued)

Phase	Process	Hazards (FAROA Related)	Possible Operational Consequences	Contributory FAROA Causes	Typical Avoidances	Mitigations	Hazard Class
		between Ownship and traffic (e.g., caused by OS position error, map error, etc.)		Improper FAROA Maintenance Incorrect FAROA Database		with other redundant info. (e.g., visual).	
		P2.FC3.H6: Crew misinterprets FAROA CDTI Information	> Surface collision > Erroneous maneuver > Increased work load	Flight Crew error reading CDTI correctly.	> Crew training > Good human factors design	Operational procedures and Flight Crew cross check with other redundant info. (e.g., visual).	4
P3. Takeoff	P3.ATC: [All processes]	Identical to current procedures.					N/A
	P3.FC1: Adjust CDTI to support Takeoff task	P3.FC1.H1: same as P2.FC1.H1	same as P2.FC1.H1 row	same	same	same	same
	P3.FC2: Use FAROA CDTI to support position determination for reporting to ATC	P3.FC2.H1: same as P2.FC2.H1	same as P2.FC2.H1 row	same	same	same	same
	P3.FC3: Use CDTI to support Identifying/ Monitoring Traffic	P3.FC3.H1 through P2.FC3.H6: same as P2.FC3.H1 through P2.FC3.H6	same as P2.FC3.H1 through P2.FC3.H6 rows	same	same	same	same
P4. En Route Decent & Initial Approach	P4.ATC: [All processes]	Identical to current procedures.					N/A
	P4.FC1: Adjust CDTI to support Decent & Initial Approach task	P4.FC1.H1: same as P2.FC1.H1	same as P2.FC1.H1 row	same	same	same	same
	P4.FC2: Use CDTI to support Identifying/ Monitoring Traffic	P4.FC2.H1 through P4.FC2.H6: same as P2.FC3.H1 through P2.PC3.H6	same as P2.FC3.H1 through P2.FC3.H6 rows	same	same	same	same

Table F-2 Operational Hazards and Potential Consequences Analysis for FAROA (continued)

Phase	Process	Hazards (FAROA Related)	Possible Operational Consequences	Contributory FAROA Causes	Typical Avoidances	Mitigations	Hazard Class
P5. Final Stages of Approach and Landing	P5.ATC: [All processes]	Identical to current procedures.					N/A
	P5.FC1: Adjust CDTI to support Final Approach & Landing task	P5.FC1.H1: same as P2.FC1.H1	same as P2.FC1.H1 row	same	same	same	same
	P5.FC2: Use CDTI to support Identifying/ Monitoring Traffic	P5.FC2.H1 through P5.FC2.H6: same as P2.FC3.H1 through P2.PC3.H6	same as P2.FC3.H1 through P2.FC3.H6 rows	same	same	same	same

Notes:

1. *Flight crews that use FAROA to supplement their ownship and traffic situational awareness must use approved safe procedures (e.g., see and avoid, ATC runway occupancy control) and should not rely on the supplementary FAROA information. The flight crew must be trained appropriately to interpret the FAROA CDTI, including that it is common for traffic targets to be missing from the CDTI. Traffic targets may be missing on the FAROA CDTI for a variety of reasons including, for example, the fact that not all traffic targets will be ADS-B participants or will be covered by a ground surveillance system and broadcast on TIS-B, equipment failures, crew-selected traffic filtering, data link interference, insufficient quality ADS-B / TIS-B reports for supporting the FAROA application, etc.*

2. *Undetected failures that occur during the setup phase have the potential to cause hazards when the equipment is used to support the four FAROA operational phases 2 through 5. Rather than including this "setup" error in the table for each of these four operational phases, the most severe hazard level associated with these operational phases is indicated in the Table with the setup phase hazard.*

F.2.3.2 Failure Modes and Effects Analysis

A Failure Modes and Effects Analysis (FMEA) was conducted on the FAROA flight crew interface referred to as the Cockpit Display of Traffic Information (CDTI). The CDTI is the single flight crew interface to obtain information from the FAROA system. This is the interface where FAROA system failures manifest themselves in a manner whereby erroneous or missing information provided to the flight crew may in rare instances lead to an adverse operational effect. The FMEA is a bottom-up analysis starting with identifying the failure modes and working back to identify their potential operation effects.

Five types of failure modes have been identified for the CDTI used for the FAROA application. These include:

1. Unmistakably failed CDTI
2. Missing information on CDTI
3. Misleading information displayed on CDTI without warning (i.e., undetected)
4. "Degraded information displayed with warning" (i.e., detected) [see note *]
5. "Flight crew error reading / interpreting the CDTI" [see note *]

Note: *The fourth and fifth failure modes are highlighted in quotes above. The reason for this notation is that FMEAs typically consider only equipment failures and do not generally address the effects of human errors (as do the fourth and fifth failure modes). However, the objective of the analysis was to determine the ways in which the FAROA system may contribute to the undesirable operational consequences.*

The first failure mode (unmistakably failed CDTI) refers to a condition where the display is blank, or is in a state that unmistakably indicates that the CDTI is not functioning properly. Such a failure mode is readily detected by the flight crew; however, it may cause the flight crew some level of distraction.

The second failure mode (missing information on CDTI) refers to a condition where relevant information is missing from the display. Such information may be with regard to ownship, traffic, or the underlying surface map. Ownship missing information should be readily identifiable by the flight crew. However, traffic vehicle missing information is not readily noticed without crew visual correlation with traffic targets. The FAROA CDTI should be used in a supplementary manner since equipment failures or non-participating aircraft/vehicles can cause traffic targets not to appear on the CDTI. Runway map information could be "missing" or may not be up to date caused by construction changes at the airport.

The third failure mode (misleading information displayed on CDTI without warning) includes the set of failures associated with misleading information presented to the flight crew on the CDTI. Such misleading information could be with regard to ownship, traffic vehicles, or the surface map. Misleading information generally results from undetected failures of the FAROA equipment including, for example, the Navigation subsystem, FAROA processing, CDTI, ADS-B, etc. The misleading information could also result from “rare normal performance” of the navigation system (e.g., on the tails of the performance distribution).

The fourth failure mode (degraded information displayed with warning) includes the set of failures associated with degraded information that is displayed and the “warning” indication is neglected or not noticed by the flight crew. Such degraded information could be with regard to ownship or traffic.

The fifth and final failure mode includes the generic set of “failures” (or more accurately labeled human errors) associated with the flight crew misreading or misinterpreting the CDTI.

Table F-3 summarizes the potential operational effects/hazards associated with the five failure modes described above. There are four significant operational consequences identified that may result from FAROA CDTI system failures. These four consequences include 1) surface collision, 2) erroneous maneuver, 3) leaving the prepared surface, and 4) increased workload (e.g., flight crew confusion/distraction). As indicated by the Fault Trees Analyses of these operational hazards (presented in Section F.1.1.1), several mitigations reduce the probability that a FAROA-related failure would contribute to a serious operational consequence (e.g., surface collision).

Table F-3 CDTI Failure Modes and Effects Table

Table Nomenclature: F = Failure Mode, ATC = Controller (Ground or Ramp), FC = Flight Crew

CDTI Failure Mode	Failure Sub-mode	Failure Description	Potential Operational Effect	Potential Operational Consequence	Hazard Class
F1. Lack FAROA CDTI Display (Detected Failure)	None	Display blank, or the display is in a state that unmistakably indicates that the CDTI is not functioning properly.	Increased workload / distraction if flight crew tries to get system working.	> Increased Workload (Confusion / Distraction)	5
F2. Missing Information	F2.1 Missing ownship symbol [Note 1]	CDTI does not display ownship symbol	This situation could lead to increased workload and distraction, but should be obvious that the CDTI is not working properly. The ownship is expected to be at a fixed location on the display, and the map displayed is based on ownship position.	> Increased Workload (Confusion / Distraction)	4
	F2.2 Missing Traffic Targets	CDTI display does not present flight crew with all traffic targets within the area of interest.	The flight crew is not presented with the information that they are expecting the FAROA CDTI to provide. They need to be vigilant cross checking traffic with other information sources (e.g., visual).	> Surface Collision > Increased Workload (Confusion / Distraction)	4 [Note 3]
	F2.3 Missing Map [Note 2]	CDTI display does not show the map to the flight crew	This situation could lead to increased workload and distraction, but should be obvious that the CDTI is not working properly.	> Increased Workload (Confusion / Distraction)	4
F3. Misleading information displayed without "warning" indication (Undetected Failure)	F3.1 Ownship state error ["state" includes entire state data (e.g., position, ground speed, heading, time of applicability, etc.]	a. The position source used to determine ownship position is significantly in error. b. The CDTI incorrectly displays the state information.	Significant ownship position errors could make it difficult to correlate map with current location and the position of the traffic targets relative to ownship.	> Surface Collision > Erroneous Maneuver > Increased Workload (Confusion / Distraction)	4

Table F-3 CDTI Failure Modes and Effects Table (continued)

CDTI Failure Mode	Failure Sub-mode	Failure Description	Potential Operational Effect	Potential Operational Consequence	Hazard Class
	F3.2 Traffic state error [one or more in the incorrect position]	Position/state of one or more traffic targets in the area of concern is significantly in error.	Significant traffic position/ state errors could make it difficult to correlate traffic with other information. Traffic position/state errors could lead crew to making incorrect decisions.	> Surface Collision > Erroneous Maneuver > Increased Workload (Confusion / Distraction) > Leaving Prepared Surface	4
	F3.3 Fictitious (non-existent) Traffic Targets added	CDTI display shows non-existent traffic targets.	Increased workload. This could cause confusion when trying to correlate traffic with other information.	> Erroneous Maneuver > Increased Workload (Confusion / Distraction) > Leaving Prepared Surface	4
	F3.4 Traffic ID error	Traffic target is misidentified.	This could cause confusion when trying to correlate traffic with other information.	> Increased Workload (Confusion)	4
	F3.5 Map error	The map incorrectly depicts the airport environment. Such an error could (for example) include: missing obstacles, incorrect runways, improperly positioned taxiways adjoining the runways, the complete incorrect map (e.g., pulls up DCA map when at ORD), etc.	Flight crew could believe the map displayed, rather than the paper map leading to erroneous maneuvers. Confusion over whether map displayed is correct, or the paper map is correct.	> Erroneous Maneuver > Increased Workload (Confusion / Distraction)	4
F4. Degraded information displayed with “warning” indication (i.e., detected)	F4.1 Ownship state/position information marginal (e.g., below minimum desired NAC, NIC, and/or SIL)	Ownship information is excessively in error and is displayed with a warning (e.g., the GPS ownship position source only has 4 satellites and cannot RAIM protect the position).	The flight crew could operate neglecting or failing to notice the warning indication for information that (had it not been “flagged” with a warning) would be classified as hazardously misleading information. Even if the flight crew notices the warning indication, the information could be significantly in error causing increased workload, confusion, and distraction.	> Surface Collision > Erroneous Maneuver > Increased Workload > Confusion / Distraction	4

Table F-3 CDTI Failure Modes and Effects Table (continued)

CDTI Failure Mode	Failure Sub-mode	Failure Description	Potential Operational Effect	Potential Operational Consequence	Hazard Class
	F4.2 Traffic state/position information (for one or more traffic targets) is marginal (e.g., below minimum desired NAC, NIC, and/or SIL)	Degraded traffic information is excessively in error and is displayed with a warning (e.g., the traffic vehicle's GPS position source only has 4 satellites and cannot RAIM protect the position).	The flight crew could operate neglecting or failing to notice the warning indication for information that (had it not been "flagged" with a warning) would be labeled as hazardously misleading information. Even if the flight crew notices the warning indication, the information could be significantly in error causing increased workload, confusion, and distraction.	> Surface Collision > Erroneous Maneuver > Increased Workload (Confusion / Distraction) > Leaving Prepared Surface	4
F5. Flight Crew Error Reading / Interpreting the Information	None	This is not really a "CDTI failure" that typically appears on an FMEA analysis. But it could be a human factors design error associated with the display. Such an error could also be caused by insufficient crew training, or even just a simple human error misreading/ misinterpreting the CDTI.	The flight crew could operate their aircraft with a distorted perception of their traffic and position situational awareness.	> Surface Collision > Erroneous Maneuver > Increased Workload (Confusion / Distraction) > Leaving Prepared Surface	4

Notes:

1. *When the CDTI field of view includes the region where the ownship position is located, the failure sub-mode of missing ownship symbol on the FAROA CDTI is precluded by a functional requirement. It is acceptable, but not a minimum requirement, for the FAROA display field of view to be adjusted (i.e., panned) to regions where the ownship position is outside the display field of view.*

2. *A missing map failure sub-mode is precluded by a FAROA functional requirement to only display ownship and traffic position when the surface map is available.*

3. *See Note 1 below in Table F-2.*

F.2.3.3 Fault Tree Analysis

[JMW Editorial Note – The Fault Tree Analysis (Section D.1.2.2.3 and all subsections) needs additional work for FAROA. Documenting the FAROA Fault Trees has been put on hold pending the results of SC-186 WG-4 methodology coordination with FAA aircraft certification. The FAROA fault trees and results are very similar to those for the ASSA application analysis.]

Fault Tree Analysis is a technique typically used for determining the likelihood of an undesirable event – called the top event. Fault trees are constructed from the top down, so the first step in the analysis is to identify the top events. The next step is to rigorously identify all combinations/sequences of events that can lead to causing the top event (i.e., constructing the fault trees). Finally, analysis of the fault trees is done to obtain a better understanding of the system and the way that the system can fail. Such information is often very useful during the system design phase to identify and alter the system design to reduce the likelihood of top event failures.

There are at least two ways to analyze fault trees. One way is a quantitatively and the second is qualitatively. During a quantitative analysis, probabilities or statistical distributions are assigned to the events and a statistical analysis is done to determine the statistical probability of the top event. During a qualitative analysis, the fault trees are used to ascertain relative performance or to get a better understanding of the system and the different ways that it can fail.

For the FAROA application, the fault tree analysis was done qualitatively.

F.2.3.3.1 Operational Consequences

There are four significant potential undesirable operational consequences (i.e., top events) identified for using FAROA to support surface movement including:

1. Surface collision

2. Leaving prepared surface

3. Erroneous maneuvers

4. Increased work load (confusion/distraction)

These top-level undesirable operational consequences are identical to those presented in the preceding sections.

A single undesired event does not necessarily initiate the top-level operational consequence. Instead, typically a sequence of two or more events is necessary to cause the top-level consequence. This sequence of events is depicted by the fault tree. The fault trees encompass both the hazards identified in the hazard analysis and the failure modes identified in the FMEA. These hazards and failure modes are caused by the basic events identified in the fault tree. The hazard analysis and FMEA provide a checklist of hazards and failures for inclusion in the fault trees.

F.2.3.3.2 Fault Trees

The following figures (Figure F-5 through Figure F-14) contain the fault trees and sub-trees identifying the sequence of events that lead to the undesired top-level operational consequences. Sub-trees are used for convenience to group a portion of the total fault tree into smaller sections that can be easily depicted on one page and/or referred to by more than one higher-level tree.

F.2.3.3.2.1 Surface Collision

To be written.

F.2.3.3.2.2 Leaving Prepared Surface

To be written.

F.2.3.3.2.3 Erroneous Maneuvers

To be written.

F.2.3.3.2.4 Increased Work Load (Confusion/Distraction)

To be written.

F.2.3.3.3 Fault Tree Analysis Results

To be written.

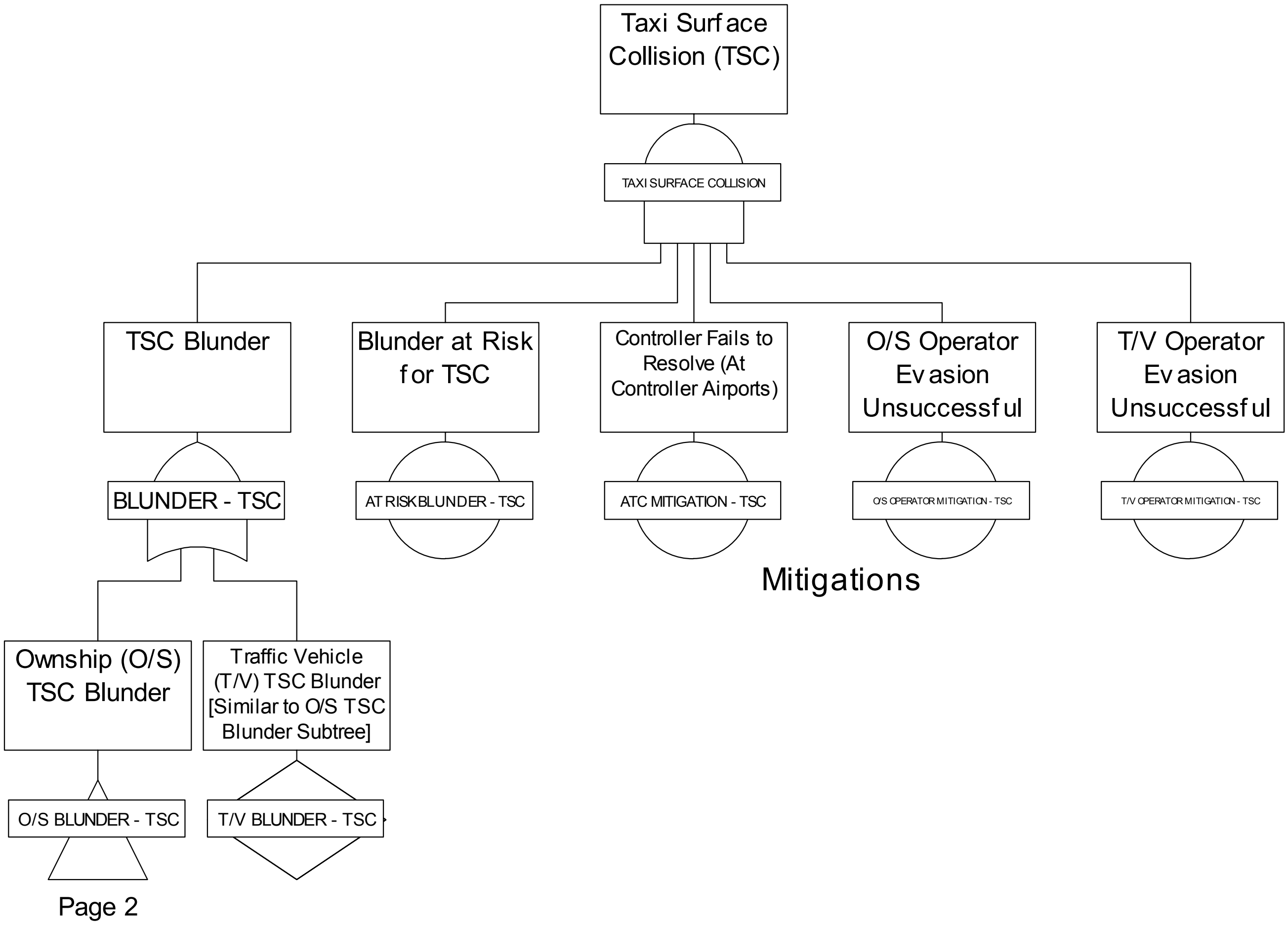


Figure F-5 Top: Surface Collision Fault Tree [Page 1]

[JMW Editorial *Note:* All of the fault trees are for the ASSA application, not FAROA as needed for this application analysis. Documenting the FAROA Fault Trees has been put on hold pending the results of SC-186 WG-4 methodology coordination with FAA aircraft certification. The FAROA fault trees are very similar to those for ASSA.]

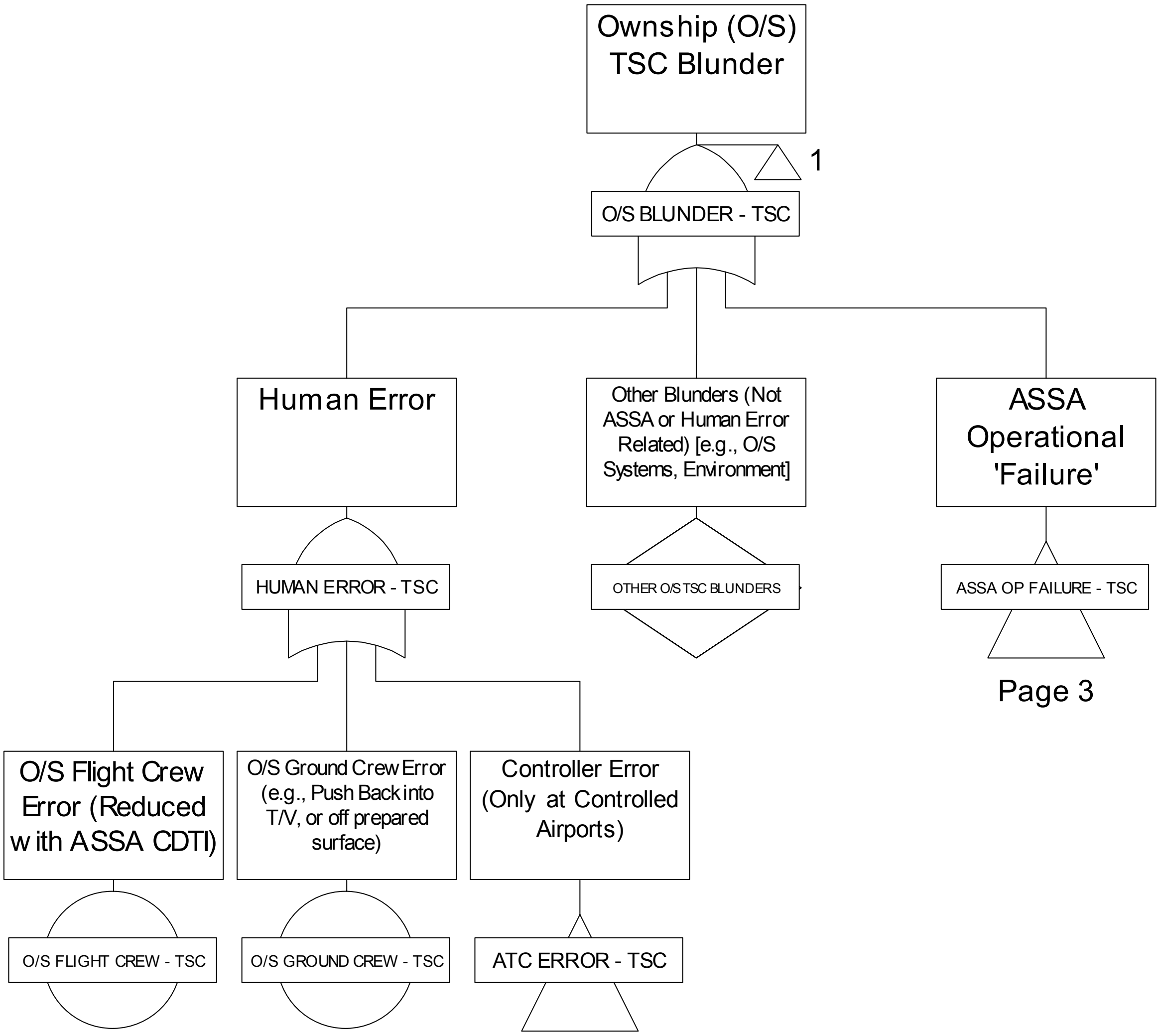
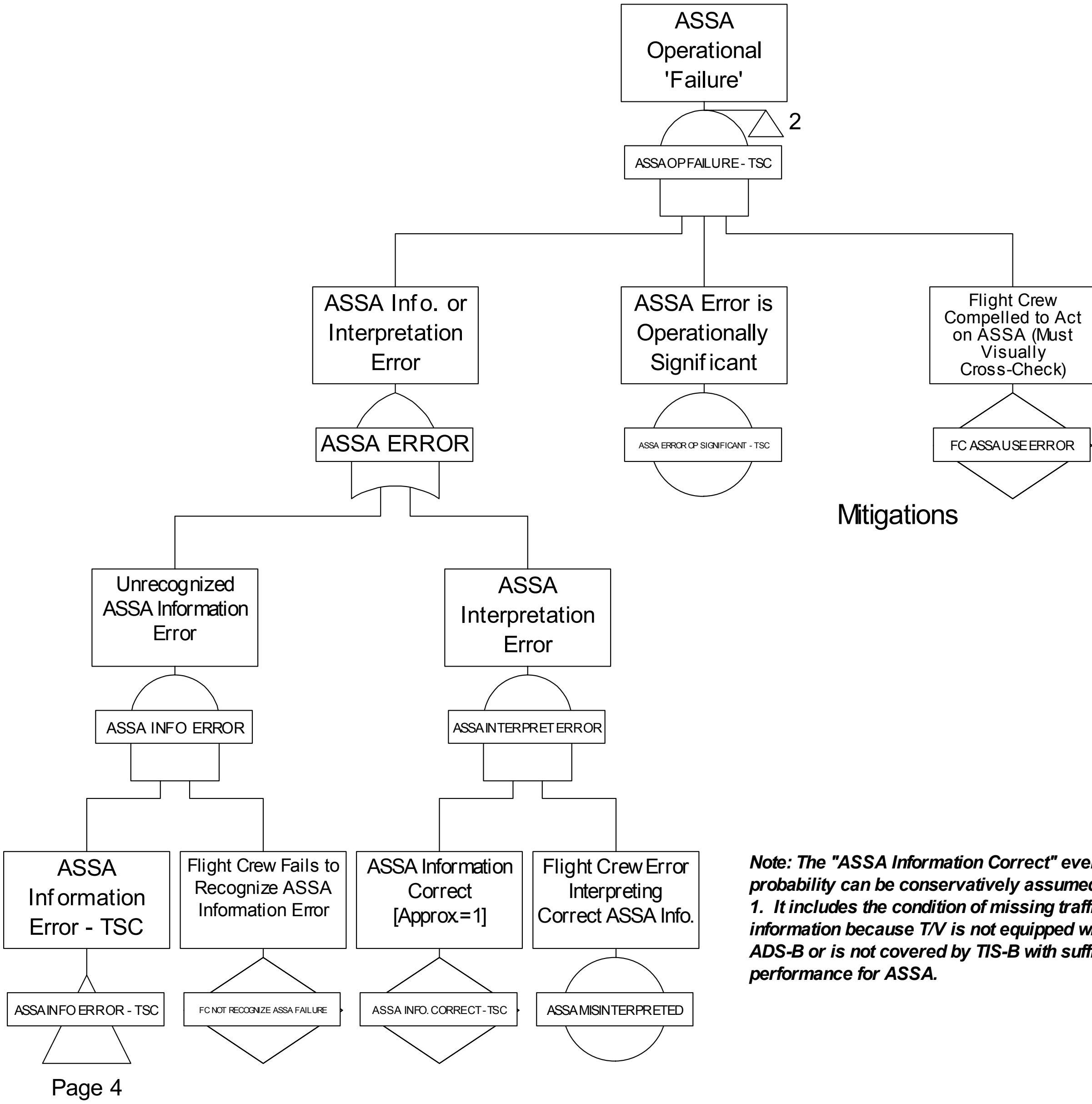


Figure F-6 Sub-Tree: Blunder for Taxi Surface Collision [Page 2]



Note: The "ASSA Information Correct" event probability can be conservatively assumed to be 1. It includes the condition of missing traffic information because T/V is not equipped with ADS-B or is not covered by TIS-B with sufficient performance for ASSA.

Figure F-7 Sub-Tree: New FAROA CDTI-Related Operational Failures [Page 3]

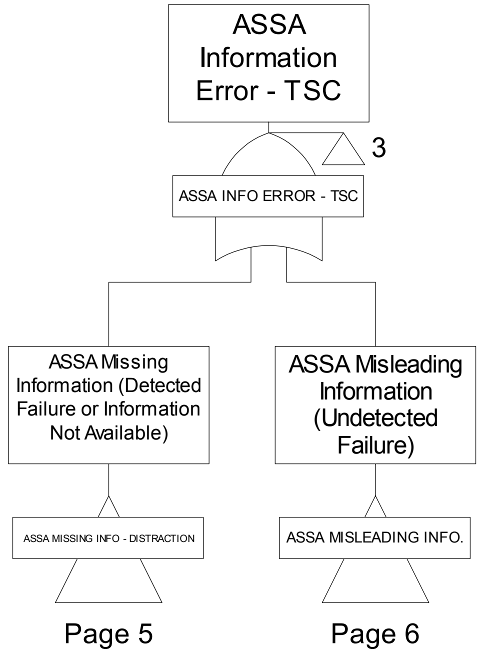


Figure F-8 Sub-Tree: FAROA Missing or Misleading Information [Page 4]

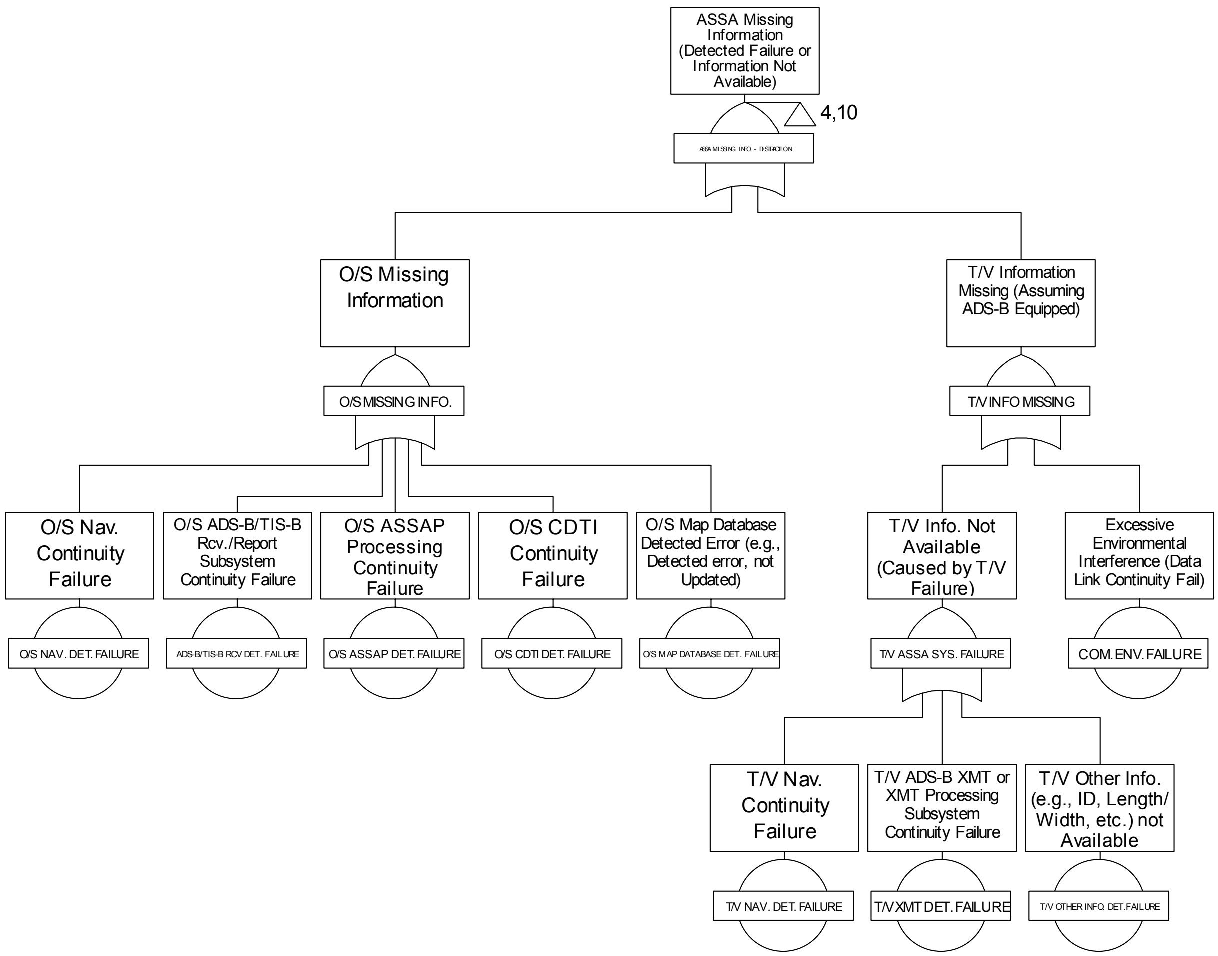


Figure F-9 Sub-Tree: FAROA Missing Information [Page 5]

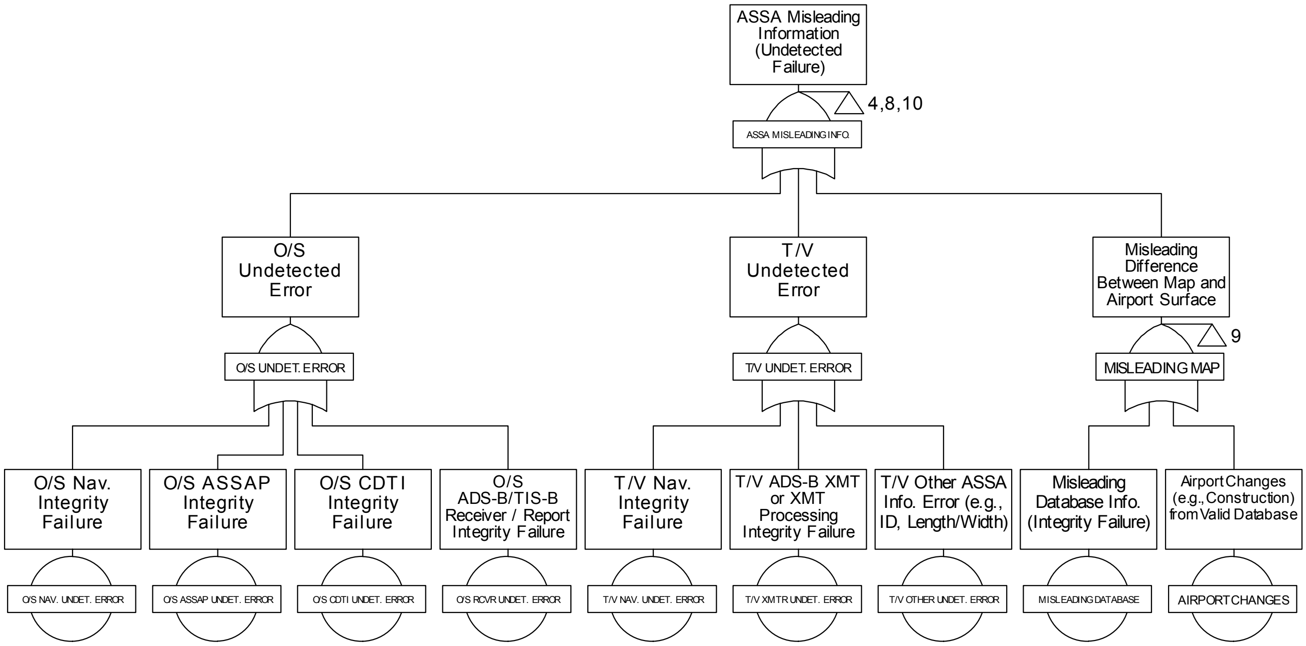


Figure F-10 Sub-Tree: FAROA Misleading Information [Page 6]

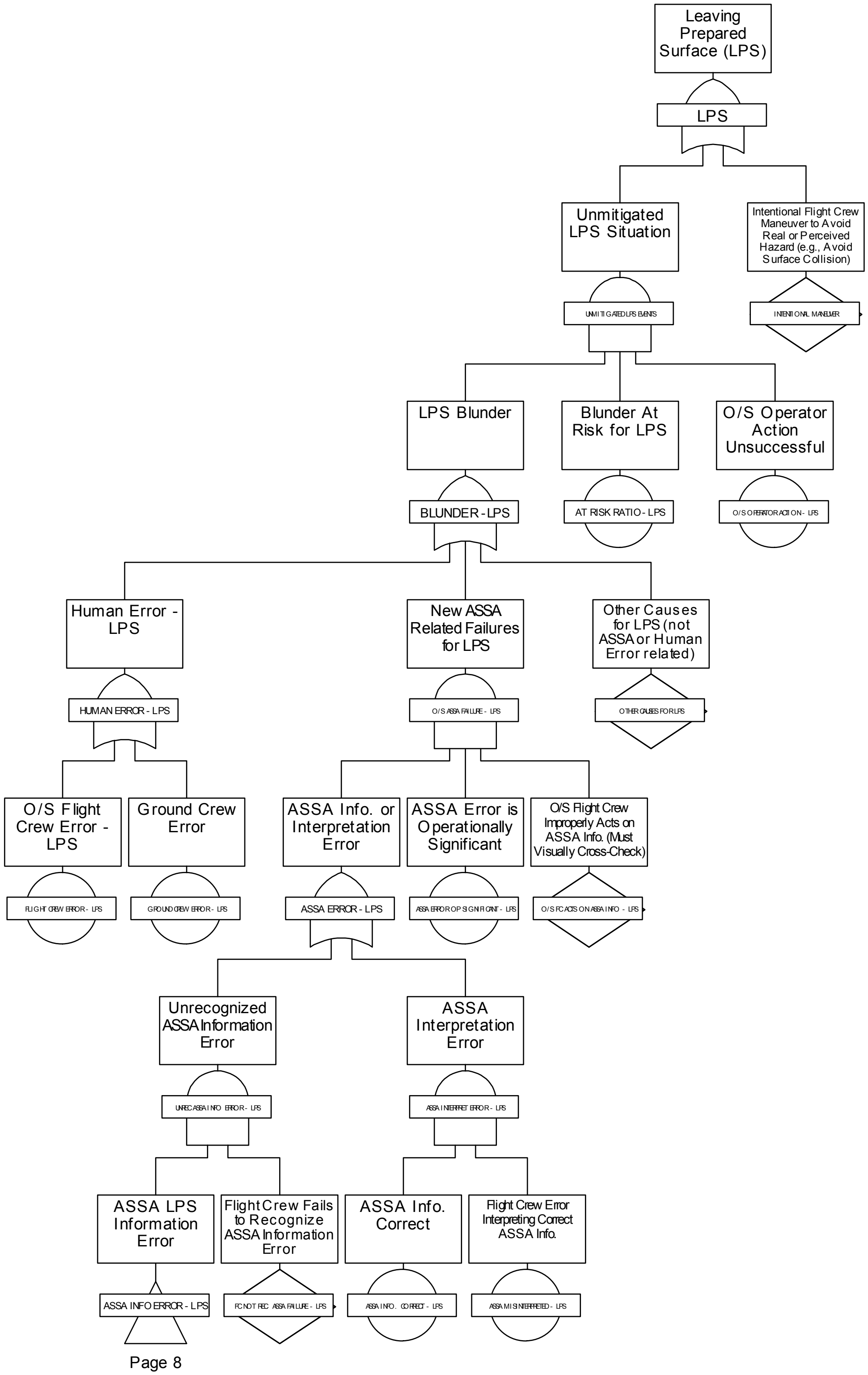


Figure F-11 **Top: Leaving Prepared Surface Fault Tree [Page 7]**

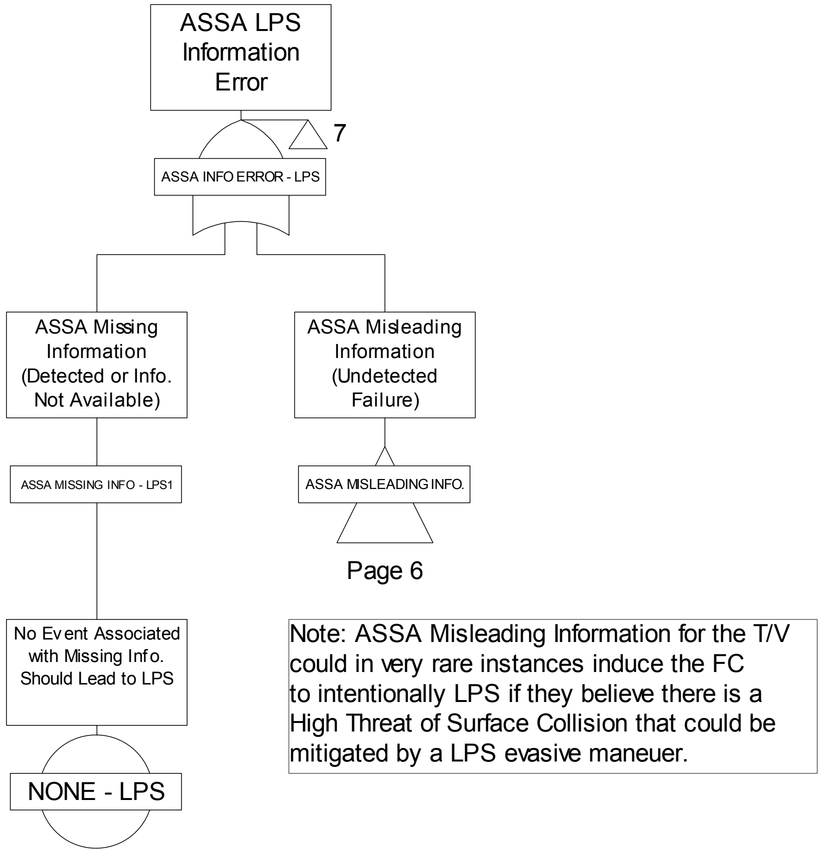


Figure F-12 Sub-Tree: Information Error for LPS [Page 8]

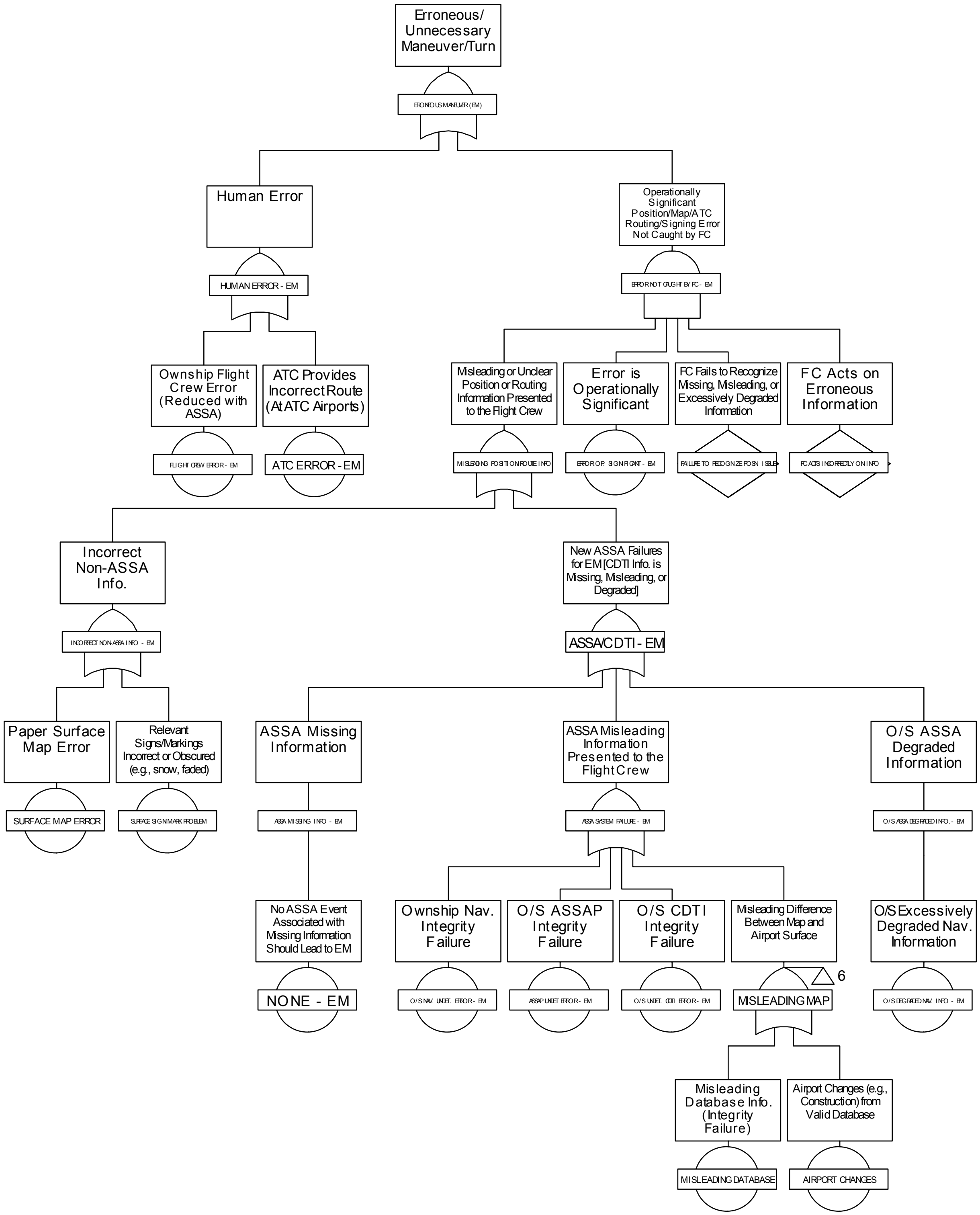


Figure F-13 **Top: Erroneous/Unnecessary Maneuver Fault Tree [Page 9]**

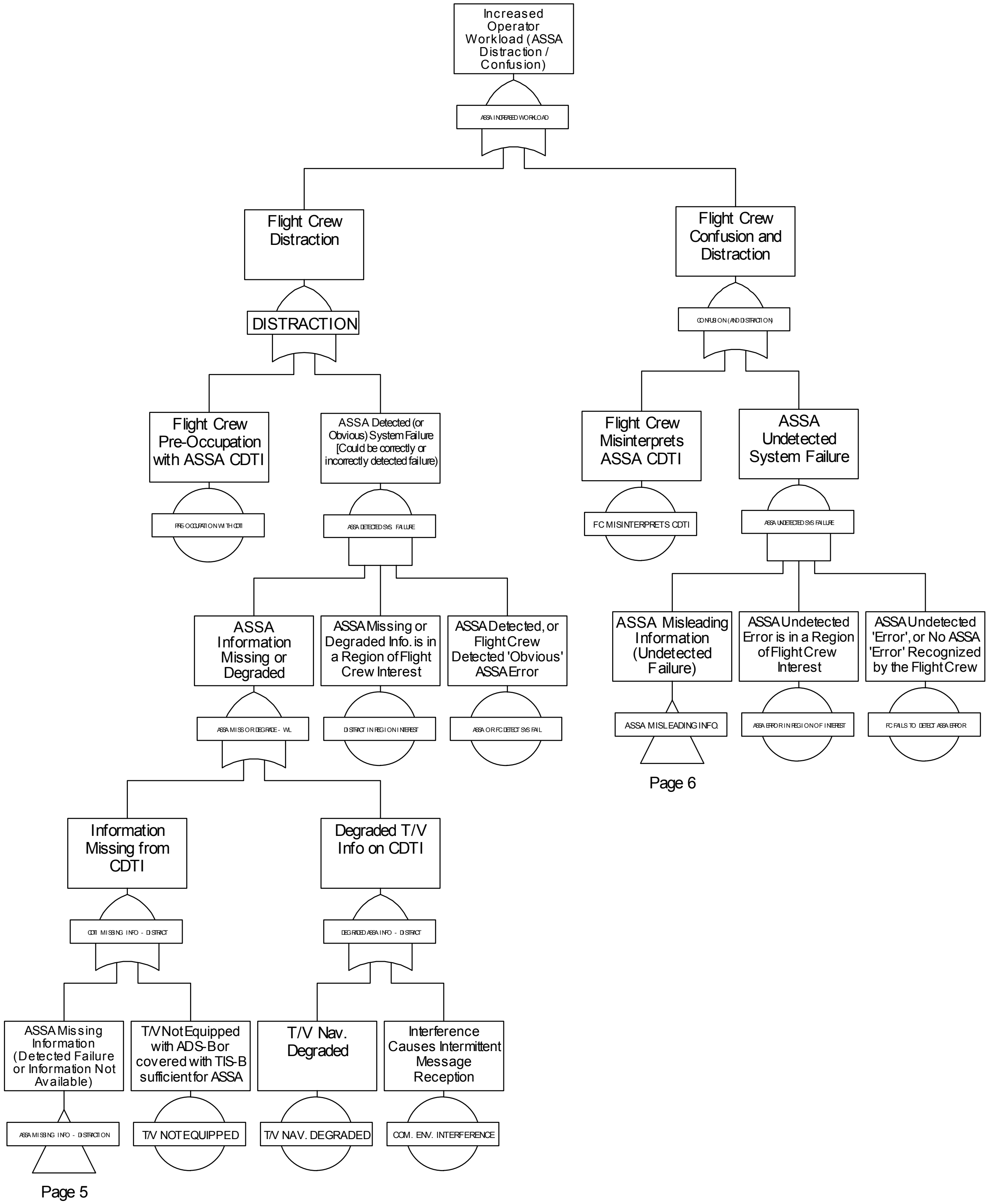


Figure F-14 Top: Increased Operator Workload Fault Tree (Confusion/Distraction) [Page 10]

F.2.4 Analysis of Surveillance Requirements to Support FAROA

This section presents the rationale for establishing the surveillance requirements for supporting the FAROA application. The surveillance requirements parameters relevant to the FAROA application include accuracy, integrity, continuity, availability, coverage, latency, update rate, time to alert, and maximum age of applicability for use of State Data (SD) information. Note that the high-level functional requirements for the Cockpit Display of Traffic Information (CDTI) associated with the FAROA application are captured in Section F.2.5.3. The combination of the surveillance performance parameters and functional requirements are sufficient to capture the high-level requirements for the FAROA application.

This section begins with an overview of the approach for establishing the performance requirements. Next, the airport physical characteristics relevant to the FAROA application are described. Finally, the requirements and their rationale are presented based upon the FAROA operational concept, safety analyses, airport characteristics, and engineering judgment. Note that all of the performance requirements from Section F.2.4 are summarized in Section F.2.5.

F.2.4.1 Performance Requirements Rationale Overview

FAROA system performance requirements have been established considering the factors that affect the usability and safety of the system within its operational context. The basic objective of FAROA is to provide the flight crew with increased runway occupancy awareness while having an acceptably small potential for increasing confusion or distraction. Based upon the baseline FAROA application description, the performance analysis did <u>not</u> consider the inclusion of any alerting functions associated with the FAROA application.

Establishing the performance requirements is a multi-facetted tradeoff that must consider many factors. Some of these factors include a) the intended operational use, b) the environment where the application will be used, c) the human factors "usability" of the system, d) the potential safety benefits and risks at the specified level(s) of performance, e) the performance of existing systems/subsystems that may be used for the application (e.g., GPS standard positioning service without requiring augmentation), f) the specified or expected performance of future systems/subsystems (e.g., ADS-B, TIS-B), g) already defined performance metrics and quantizations [e.g., ADS-B quantizations for NACp, NACv, NIC, SIL], h) the availability and pedigree of current and expected future surface map databases, i) cost, and j) the time frame for implementation.

The requirements specified herein have built on the requirements specified for the "Aerodrome Moving Map Display (AMMD)" in RTCA/DO-257A [ref. 1].

<u>Note:</u> *The FAROA application includes the display of traffic information from participating vehicles on the CDTI in addition to ownship/surface moving map information. The requirements for applications that only provide ownship surface moving map information and do <u>not</u> provide traffic situational awareness may be different (e.g., less stringent) than those defined for the FAROA application.*

Three information quality states have been assumed for qualifying information for each traffic vehicle received via ADS-B or TIS-B including:

1. good quality

2. degraded quality, and

3. insufficient quality.

The first state of "good quality" is where traffic information is available that meets the minimum performance requirements for good situational awareness. The second state of "degraded quality" is where traffic information is available, but it is of reduced or degraded quality where it is still believed helpful for situational awareness with an appropriate "degraded" indication. The third state "insufficient quality" is where information about a traffic vehicle is available, but it lacks sufficient quality such that it is not likely to enhance situational awareness. Furthermore, for this third state, there is an unacceptably high probability that if the traffic target were displayed it could lead to flight crew confusion or distraction.

Note: *For traffic vehicle information that is of "insufficient quality" (the third state), it is required to remove that traffic target's position symbol from the CDTI, with two exceptions. Firstly, if the heading or track accuracy performance is unacceptable, the traffic symbol is required to be shown with a non-directional symbol when all other conditions for continuing to display the symbol are satisfied. Secondly, if the position accuracy as indicated by NACp degrades to the level of unacceptable performance, it is acceptable to either remove the traffic position symbol from the display, or provide an indication of the position uncertainty (e.g., 95% error region).*

In order to develop the FAROA performance requirements to meet the application's operational objectives, three high-level FAROA system requirements were established including:

1. Relevant ownship and traffic vehicle position and heading shall be provided, and velocity and identification information shall be able to be provided, if the appropriate data is available and of sufficient quality. In addition, the ownship and traffic vehicle symbology shall be representative of the vehicle size when the display is sufficiently zoomed and valid size information is available.

2. Vehicle positions shall be shown correctly on the CDTI such that vehicle/airport features are positioned correctly relative to one another. In other words, display the ownship and traffic vehicle positions close enough to their true position relative to the underlying map such that flight crew confusion and distraction about where the vehicles are is minimized.

3. The application shall indicate when the information quality degrades below the minimum acceptable levels.

Specific quantitative performance requirements and their rationale are presented below following a description of airport characteristics relevant to FAROA. The FAROA performance requirements baseline has been established considering all the factors identified above.

F.2.4.2 Physical Airport Characteristics Relevant to FAROA Application

In order to establish the quantitative FAROA requirements, including for example positioning accuracy, knowledge of the physical characteristics of airports is necessary. This includes the physical size of runways and the relative separation distances between the runway and other markers like the hold short line. The FAROA application requirements are based on providing a display indicating ownship and traffic positions overlaid on a runway map that may be useful to support determining runway occupancy.

F.2.4.2.1 Width of Runways

Width of runways varies with the type of airport. The minimum width of runways and taxiways is provided in Table F-4 as a function of the aerodrome code letter and aerodrome code number, as defined in ICAO Annex 14 [ref. 3, section 1.3].

Note: Airports (referred to as aerodromes by ICAO) are categorized using two parameters including aerodrome code number and aerodrome code letter. These parameters are defined in ICAO Annex 14 [ref. 3, section 1.3].

Table F-4 Minimum Width Runway Design Standards by Aerodrome Code Number and Letter [ref. 3, sections 3.19, 3.83, & 3.84]

Airport Surface	Aerodrome Code Number [b]	Minimum Width (meters) as a function of Aerodrome Code Letter [b]				
		A	B	C	D	E
Runway	1 [a]	18	18	23	—	—
	2 [a]	23	23	30	—	—
	3	30	30	30	45	—
	4	—	—	45	45	45

Notes:
a. The width of a precision approach runway should be not less than 30 m where the aerodrome code number is 1 or 2.

b. Refer to ICAO Annex 14 [ref. 3, section 1.3] for a definition of the aerodrome code numbers and code letters.

F.2.4.2.2 Minimum Separation Distance from Runway to Holding Positions

In addition to considering the physical width of the runway, the minimum distance between the runway and the hold short line also needs to be considered.

The minimum distance between a holding bay, taxi-holding position established at a taxiway/runway intersection or road-holding position and the centerline of a runway must be in accordance with Table F-5 based on ICAO Annex 14 [ref. 3, section 3.11.5].

Table F-5 Minimum Distance from Runway Centerline to Holding Bay, Taxi-Holding Position, or Road-Holding Position [ref. 3, section 3.11.5]

Type of Runway	**Code Number [3]**			
	1	**2**	**3**	**4**
Non-instrument	30m	40m	75m	75m
Non-precision approach	40m	40m	75m	75m
Precision approach category I	60m [2]	60m [2]	90m [1, 2]	90m [1, 2]
Precision approach categories II and III	–	–	90m [1, 2]	90m [1, 2]
Take-off runway	30m	40m	75m	75m

Notes:

1. *If a holding bay, taxi-holding position, or road-holding position is at a lower elevation compared to the threshold, the distance may be decreased 5 m for every meter the bay or holding position is lower than the threshold, contingent upon not infringing the inner transitional surface.*

2. *This distance may need to be increased to avoid interference with radio navigation aids, particularly the glide path and localizer facilities.*

3. *Refer to ICAO Annex 14 [ref. 3, section 1.3] for a definition of the aerodrome code numbers and code letters.*

F.2.4.2.3 Most Demanding Runway Incursion Scenario Separation Distance

The FAROA application goal is to reduce runway-related incidents/accidents. Figure F-15 illustrates five common runway incursion scenarios that may occur during taxi, takeoff, and landing. Scenario A in this figure depicts an aircraft taxiing across the runway that another aircraft is attempting to land on. Scenario B depicts a similar scenario where an aircraft taxies across a runway that another aircraft is attempting to depart on. Scenario C illustrates the condition when there is loss of separation between aircraft arriving and departing on the same runway. Scenario D depicts a conflict between operations on runways that cross. Lastly, scenario E depicts a landing situation where an aircraft waiting for takeoff has taxied past the holding position.

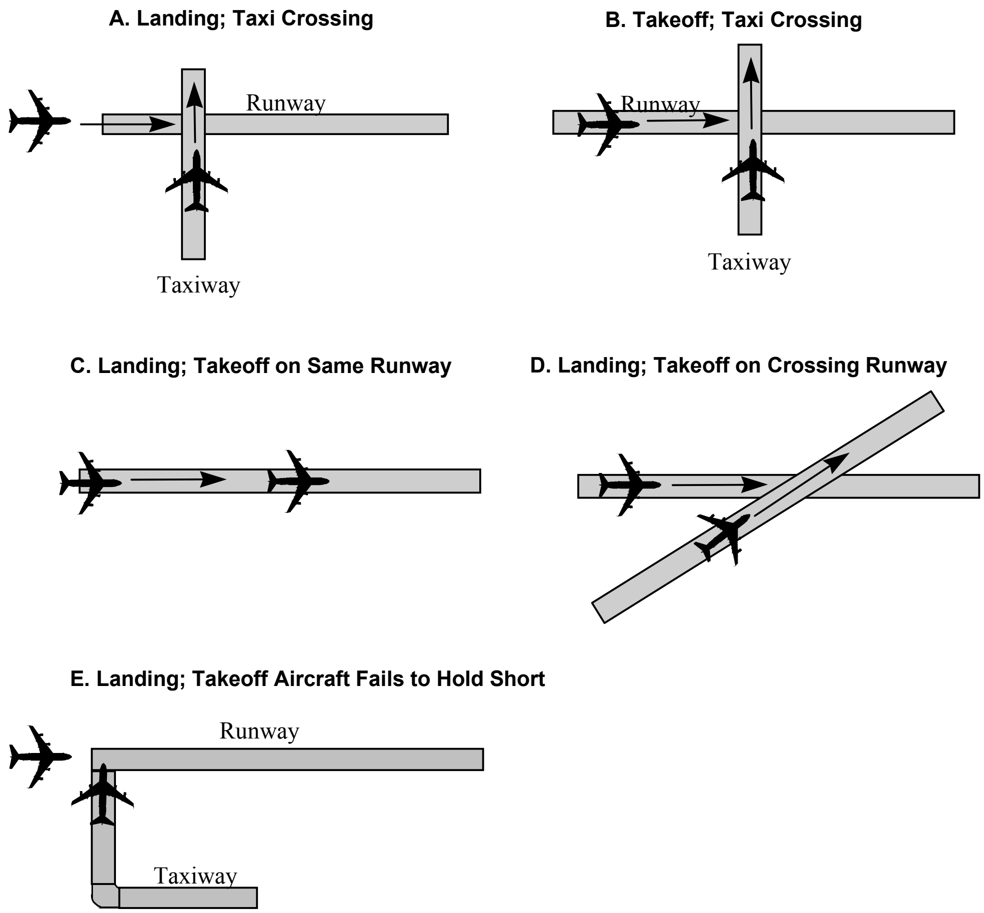
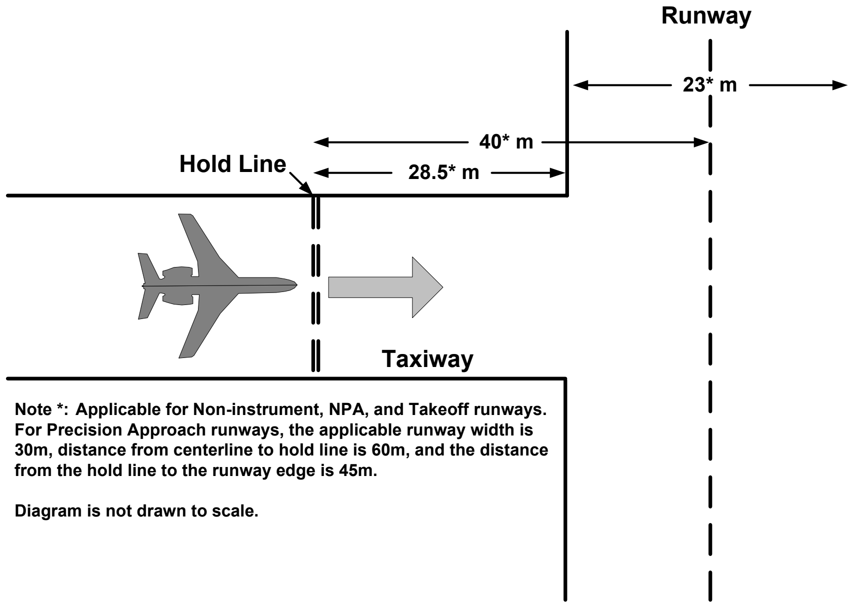


Figure F-15 Common Runway Incursion Scenarios

When considering the common runway incursion scenarios described above, the most demanding from an accuracy standpoint are those that require determining whether an aircraft has infringed on the runway or is safely holding short of the runway. This situation is essentially the case for scenarios A, B, and E in Figure F-15. The other runway incursion scenarios are less demanding from an accuracy performance standpoint. In order to assess runway occupancy, larger position errors/uncertainties are tolerable in the along runway direction than perpendicular to the runway. This observation is an important when establishing the positioning requirements for FAROA including the effects of velocity, acceleration, latency, and timing uncertainty on positioning accuracy.

For these most demanding runway occupancy incursion scenarios, it is desirable for the FAROA application to support determining whether a taxiing aircraft has infringed on the runway or is safely holding short of the runway. Figure F-16 and Figure F-17 illustrate this situation and provide the separation distance between the holding short of the runway position and edge of the runway for Aerodrome Code Numbers 2 and 4, respectively. The runway width and separation distances depicted in these figures are the minimum values from Table F-4 and Table F-5 for any type of runway (e.g., non-instrument, takeoff, etc.) with the specified Aerodrome Code Letter. As noted on these figures, the minimum runway widths and/or separation distances for precision approach runways are larger. Furthermore, the minimum separation distances for Aerodrome Code Number 2 (capable of support smaller aircraft) are much smaller than for Aerodrome Code Number 4 (capable of supporting larger aircraft).

The separation distances indicated in these figures are used as part of the rationale as described in the next section to identify the desired position accuracy requirements for FAROA traffic targets.



<u>Figure F-16</u> Runway Incursion Scenario Distances for Aerodrome Code Number 2

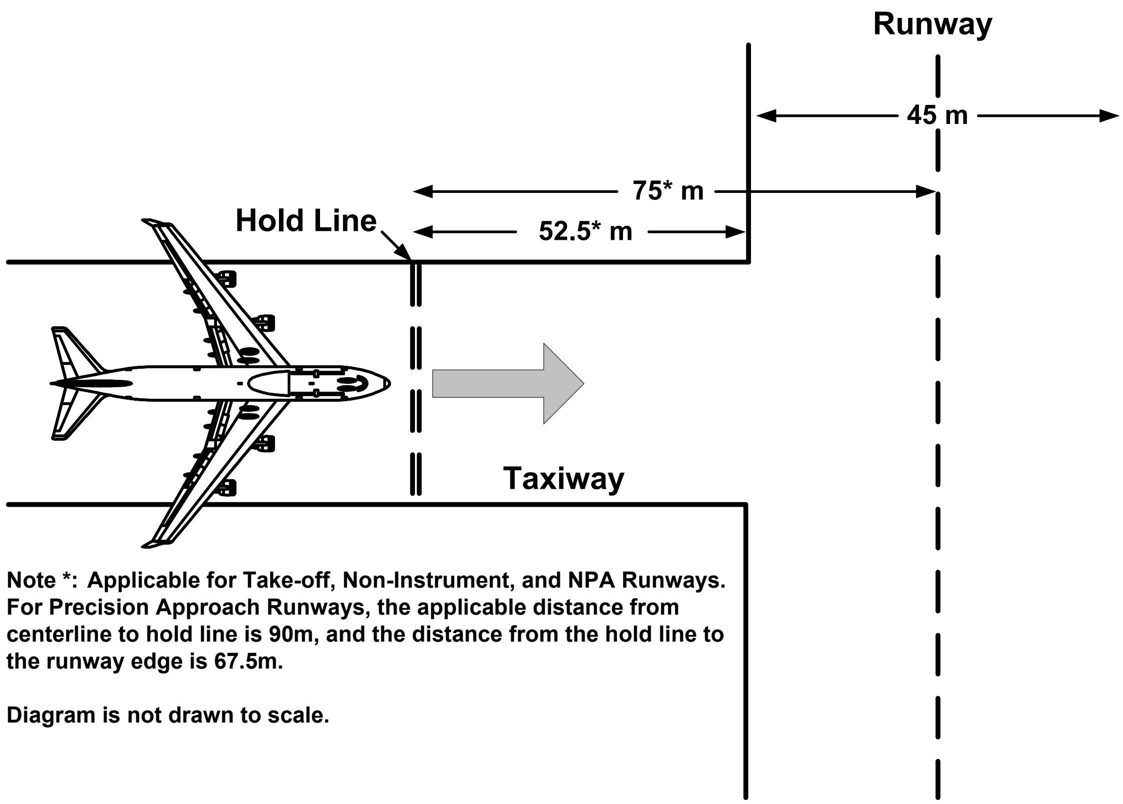


Figure F-17 Runway Incursion Scenario Distances for Aerodrome Code Number 4

F.2.4.3 FAROA Requirements Rationale

The approach taken to establish the FAROA application requirements was to use the equipment requirements established as part of the DO-257A Aerodrome Moving Map Display as the baseline and add requirements to this baseline as necessary to also address traffic. This approach considered the usability and safety of the FAROA application within its operational concept and environment.

F.2.4.3.1 Implications of the Physical Characteristics to the FAROA Requirements

It is undesirable to have the FAROA system contribute to runway occupancy confusion as to whether an aircraft is near or on the runway. As depicted in Figure F-16 for Aerodrome Code Number 2 facilities, the distance between a taxiway hold short line and the edge of the runway could be as low as 28.5 m for runways that do not support precision approach and 45 meters for those runways that do support precision approach. To avoid runway occupancy confusion, it should be infrequent that the horizontal position error exceeds half of this separation distance, or 14.25 meters. Note that this is the displayed position error relative to the underlying surface map.

The implications of the physical characteristics lead to the desirability to keep the displayed traffic horizontal position 95% uncertainty less than approximately 10 meters to reduce the probability of providing the flight crew with confusing or distracting information to an acceptable level. However, this level of performance is not required as a minimum.

F.2.4.3.2 Multifaceted Tradeoff

All the factors identified in section F.2.4.1 were considered for establishing the required performance to support the FAROA application. It is highly desirable to be able to meet the FAROA requirements with performance readily achieved with non-augmented GPS receivers such that are readily available today at a low user cost such that users can realize the safety benefits of ownship and traffic situational awareness in the runway environment as soon as possible. Furthermore, it is desirable to keep the target display criteria the same as the ASSA to reduce the application development and flight crew training costs as well as to minimize the human factors issues when interacting with both the ASSA and FAROA applications.

The performance requirements established herein are sufficient for meeting the FAROA operational objective of providing ownship position and traffic situational awareness information that may be operationally useful for catching some of the rare failures (e.g., runway incursion) in the existing safe operational procedures before the failures lead to undesired consequences. This additional information may make operations involving runway occupancy even safer. However, the performance requirements defined herein are not sufficient to unambiguously identify whether a traffic target is on or very close (i.e., holding short) to the runway.

F.2.4.3.3 Total FAROA System Position and Velocity Accuracy Goals

The total uncertainty of positioning traffic target vehicle symbols on the CDTI relative to the underlying runway map has been estimated and allocated using three equations presented and described in the ASSA application analysis (Section E.2.3.3.3, equations 1 through 3). These equations sum the squares of the uncertainties for the various error contributors (including for example, uncertainties in position, velocity, acceleration, and time) to arrive at a total position uncertainty.

Horizontal and vertical accuracy allocations have been made to the various components of error that comprise the total traffic positioning error performance.

Note that the DO-257A requirements for AMMD situational awareness application define the minimum accuracy requirements (95%) for ownship position and the database. This standard allows up to 36 meters ownship horizontal position accuracy, and a database accuracy of 43 meters on runways.

Requirements for the display will limit the acceptable display quantization. It is required by a functional requirement specified in section F.2.5.3 to be capable of zooming the display such that 1-pixel ≤ 1 meter. This will provide an acceptable quantization error when it is necessary to zoom in to assess position and traffic situations. For display zoom where 1-pixel = 1 meter, the maximum quantization error is 0.5 meters. Assuming a uniform distribution, 95% of the time the quantization error will be less than 0.475 meters.

F.2.4.3.3.1 Horizontal Total Traffic Target Accuracy Goals

The accuracy goals described below are for stopped or slowly moving vehicles that are near the runway. For fast moving vehicles, additional positional error is acceptable, especially position errors in the runway along track direction, which is in the direction of potentially higher velocities for vehicles occupying or soon to be occupying the runway.

F.2.4.3.3.1.1 Desired Performance

A reasonable value for the desired total FAROA target vehicle horizontal positional reference uncertainty allocation is 11 meters (95%) for stopped or slowly moving vehicles. This level of accuracy will nominally keep the displayed vehicle positions sufficiently correlated with the underlying map to give the operators using FAROA a good perspective on locations of traffic.

F.2.4.3.3.1.2 Minimum Performance

The minimum performance allocation for the target horizontal position accuracy is 37 meters (95%) for stopped or slowly moving vehicles. This value is judged sufficient for situational awareness.

F.2.4.3.3.1.3 Degraded Performance

It is highly desirable to meet 37 meters total target horizontal 95% accuracy for normal performance. However, if 37 meters is not achieved, it is better to provide the vehicle operator with the degraded traffic positional information as long as the accuracy meets an acceptable minimum threshold, rather than remove the information. The acceptable minimum threshold must be sufficient to reasonably identify the general location of the vehicle on the airport, while providing an indication that the information is degraded. The minimum horizontal accuracy threshold selected for still meeting degraded performance is 111 meters based upon engineering judgment considering the intended operational use of the FAROA application, airport characteristics, and already defined NAC_p quantizations defined in the DO-242A [ref. 2]. Accuracy performance below the degraded performance threshold is considered unacceptable for situational awareness, and may result in removing the traffic symbol from the display.

F.2.4.3.3.2 Vertical Total Traffic Target Accuracy Goals

Vertical position is helpful to identify aircraft in flight that may soon be occupying a runway. For example, aircraft flying high above the airport are not a concern for the FAROA application (e.g., greater than 1500 feet height above the airport surface). However, aircraft on the final stages of approach are relevant to runway occupancy. Thus, vertical position with a coarse level of accuracy is required to support determining whether or not a flying aircraft is close enough to the runway to be considered as a potential hazard. Relatively large vertical position errors are operationally tolerable for the FAROA application.

F.2.4.3.3.2.1 Desired Performance

A conservative desired value for the total FAROA vertical positional accuracy for airborne vehicles is 20 meters (95%).

F.2.4.3.3.2.2 Minimum Performance

The minimum performance allocation for the target vertical position accuracy of airborne vehicles is 60 meters (95%). This value is judged sufficient for determining whether or not a flying aircraft is close enough to the airport surface to be considered as a potential hazard.

F.2.4.3.3.2.3 Degraded Performance

It is highly desirable to meet the minimum performance vertical accuracy for airborne vehicles. However, if it is not achieved, it is better to provide the vehicle operator with the best available vertical information as long as the horizontal information has not degraded below the threshold of unacceptable performance.

F.2.4.3.4 Accuracy Allocations

The traffic position accuracy at the time of display on the ownship vehicle is comprised of uncertainties in the position reference and the state data latency.

The traffic target goals provided in sections F.2.4.3.3.1 and F.2.4.3.3.2 can be met with the appropriate allocations for velocity accuracy, latency (between the time of measurement and time of display), and report time accuracy as given in Table F-6. The velocity and acceleration assumptions used to assess the latency uncertainty are justified in section F.2.4.3.5.

Table F-6 Allocations and Assumptions for Meeting Target Accuracy Goals

		Computed (Note 1)	**Based on Received NAC_p**	**Computed (Note 2)**	**Assumptions**		**Allocations**		
	Perform-ance	Target 95% Accuracy (m)	Sensor Position 95% Accuracy (m)	Latency Uncertainty 95% Accuracy (m)	Velocity (knots)	Accelera-tion (m/s^2)	Velocity 95% Accuracy (horizontal in meters, vertical in ft/s) (Note 4)	Latency (sec) (Note 3)	95% Relative Time Uncertainty (sec)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Horizontal (Stopped/Slow Vehicles)	**Desired**	11	10 [NAC_p = 10]	4.1	15	0.5	1 m/s [NAC_V = 3]	3	0.2
	Minimum	37	30 [NAC_p = 9]	21.6	15	0.5	3 m/s [NAC_V = 2]	6	1.0
	Degraded	Unknown (Approx. ≤ 111)	< 92.6 [NAC_p = 8]	Unknown (Approx. 61.1 m with 10m/s velocity accuracy and 6 sec latency)	15	0.5	Unknown (Approx. assumes 10 m/s, [NAC_V = 1]	≤ 17 sec.	1.0
	Unacceptable	Unknown (Approx. > 111)	≥ 92.6 [NAC_p ≤ 7]	Unknown	15	0.5	Unknown	> 17 sec.	1.0
Horizontal (Fast Moving Vehicles)	**Desired**	31	10 [NAC_p = 10]	29.3	180	5.0	1 m/s [NAC_V = 3]	3	0.2
	Minimum	134	30 [NAC_p = 9]	130.4	180	5.0	3 m/s [NAC_V = 2]	6	1.0
	Degraded	Unknown (Approx. ≤ 170)	< 92.6 [NAC_p = 8]	Unknown (Approx. 142.4 m with 10m/s velocity accuracy and 6 sec latency)	180	5.0	Unknown (Approx. assumes 10 m/s, [NAC_V = 1]	≤ 17 sec.	1.0
	Unacceptable	Unknown (Approx. > 170)	≥ 92.6 [NAC_p ≤ 7]	Unknown	180	5.0	Unknown	> 17 sec.	1.0
Vertical	**Desired**	20	15 [NAC_p = 10]	10	15	1.0	5 ft/s [NAC_V = 3]	3	0.2
	Minimum	60	45 [NAC_p = 9]	35	15	1.0	15 ft/s [NAC_V = 2]	6	1.0
	Degraded	Unknown	Unknown [NAC_p = 8]	Unknown (Approx. 100m with 50 ft/s velocity accuracy and 6 sec. latency)	15	1.0	Unknown (Approx. assumes 50 ft/s, [NAC_V = 1]	≤ 17 sec.	1.0
	Unacceptable	Unknown	Unknown	Unknown	15	1.0	Unknown	> 17 sec.	1.0

Notes:

1. *Computed based upon equation 2 (in ASSA Section E.2.3.3.3) using the values in columns 4 and 5. These calculations assume that the underlying 95% accuracy indicated by the NAC_P encoding is at the highest value in the quantization range.*

This is conservative, as the underlying accuracy will typically be smaller than the highest quantized value.

2. *Computed based upon equation 3 (in ASSA Section E.2.3.3.3) using the values in columns 6 through 10.*

3. *Latency from the target aircraft's position sensor measurement time of applicability until traffic symbol is displayed for the FAROA application on the user aircraft's CDTI.*

4. *The velocity accuracy refers to the horizontal velocity resolved into north/east components, or optionally on the airport surface the velocity accuracy refers to the groundspeed. When the groundspeed is used, the ground track or heading is necessary to resolve the directionality of the speed.*

F.2.4.3.5 Velocity and Acceleration Allocation Assumptions for the Traffic Vehicles

The accuracy of the traffic position is dominated by the position reference uncertainty and the latency uncertainty (see equation 2 in ASSA section E.2.3.3.3). The uncompensated portion of the latency leads to position errors that are related to the speed of the vehicle. Based upon possible runway and approach speeds, it is required to compensate the display for known aged state data. Furthermore, during the compensation period, accelerations for the traffic target vehicles are typically not known. Thus, typical ranges of speeds and accelerations are addressed to provide a rationale for the velocity and acceleration assumptions used in Table F-6.

F.2.4.3.5.1 Rationale for Horizontal and Vertical Velocity Assumptions

Surface speeds vary as a function of aircraft type and phase of operation as shown in Table F-7. Typically, the highest speed occurs on take off, followed by landing, high-speed taxi operations, normal taxi, and finally taxilane movements. Surface vehicular speeds range from the very slow grass-cutting tractor to the high-speed emergency vehicle. For these reasons, vehicular speeds may range from 0 to 80 knots.

Approach speeds also vary as a function of aircraft type.

Table F-7 Surface Runway and Taxi Speeds [ref. 4, p. 24]

Surface Operation (Speed in knots)	**I – A,B,C**	**II – A,B,C,D**	**III – A,B,C,D,E**	**IV – B,C,D**	**V – C, D**	**VI – C**
Take Off (Estimates)	0-150	0-150	0-180	0-170	0-160	0-150
Approach Speed	50-143	52-145	72-178	93-165	128-154	124-135
Roll Out	60-143	60-145	60-178	60-165	60-154	60-135
High Speed Taxi	30-80	30-80	30-80	30-80	30-80	30-80
Normal/Apron Taxi – Straight	10-50	10-50	10-50	10-50	10-50	10-50
Normal/Apron Taxi – Curve	10-20	10-20	10-20	10-20	10-20	10-20
Gate Area/Taxilane	0-10	0-10	0-10	0-10	0-10	0-10
Vehicle Speeds	0-80					

For the purposes of assessing the 95% error associated with target state data latency, the following 95% velocities were assumed based upon the rationale provided in the notes below: a) horizontal velocity – 15 knots for stopped/slowly moving vehicles and 180 knots for a fast moving vehicle, b) vertical velocity of 15 knots.

Notes:

1. *The 15-knot horizontal speed assumed for stopped/slow moving vehicle error allocation assessment is reasonable based upon expected taxi speed onto or across an active runway. For fast moving surface vehicles, Table F-7 identifies the maximum approach and runway operation speeds which are less than or equal to 180 knots, which is the value conservatively used for fast moving vehicles.*

2. *The 15 knot vertical speed was conservatively determined using the maximum approach speed of 178 knots from Table F-7 and a 5 degree approach glide path [178 knots * sin (5°) = 15.5 knots, which was rounded to 15 knots for the 95% error allocation].*

F.2.4.3.5.2 Rationale for Accelerations Assumptions

The maximum assumed accelerations and decelerations for surface movements are given in Table F-8.

Table F-8 Maximum Assumed Surface Movement Accelerations/Decelerations

Surface Movement Scenario	Maximum Assumed Acceleration/Deceleration
Acceleration during taxi	1 m/s^2 (0.1g)
Deceleration during taxi	2.4 m/s^2 (0.25g)
Acceleration during takeoff	5.9 m/s^2 (0.6g)
Deceleration during landing	5.9 m/s^2 (0.6g)

For the purposes of assessing the 95% error associated with target state data latency, for stopped or slowly moving vehicles (notionally taxiing toward the runway), a 95% taxi horizontal acceleration/deceleration of 0.5 $meters/second^2$ was assumed. Similarly, for error allocation purposes of fast moving vehicles, a 95% bound on the acceleration of 5.0 $meters/second^2$ was used.

Similarly, a 95% vertical acceleration/deceleration of 1.0 meter/second (0.1g) was conservatively assumed for an aircraft on approach.

This concludes the rationale for the FAROA requirements. The next section defines the FAROA system data requirements based upon the performance goals and allocations documented in the rationale section.

F.2.4.4 FAROA Data Requirements

The FAROA system data requirements are defined for 1) target state data (section F.2.4.4.1), 2) the ownship state data (section F.2.4.4.2), and 3) the airport database (section F.2.4.4.3).

The target state data requirements are further subdivided into accuracy requirements, integrity requirements, timing requirements, and other requirements. The display of traffic targets is dependent upon the quality of the received target state data, and thus the requirements are specified in terms of:

1. normal performance, which defines the both the "minimum" requirements that must be met for the display of normal good quality traffic target state information as well as "desired" performance requirements that are over and above the minimum,

2. degraded performance, which defines the level where traffic state data is of degraded quality, and

3. unacceptable" performance, which defines the level where traffic state data is of insufficient quality to provide a useful aircraft target symbol on the display.

F.2.4.4.1 Target State Data

The FAROA Target State Data performance requirements are exactly the same as those required for the ASSA application as described in ASSA section E.2.3.4.1 including all of its subsections. This includes all the traffic target performance requirements including:

- Target State Data Accuracy [ASSA section E.2.3.4.1.1]
  - Navigation Accuracy Category for position (NAC_p)
  - Navigation Accuracy Category for velocity (NAC_V)
  - Heading Accuracy
- Target State Data Integrity (i.e., NIC, SIL, and maximum delay to indicate integrity changes) [ASSA section E.2.3.4.1.2]
- Target Data Timing (i.e., effective update, report time accuracy, latency bound, and maximum coast time) [ASSA section E.2.3.4.1.3]
- Other target transmit data quality requirements (i.e., data availability, data continuity, and Transmit Quality Level) [ASSA section E.2.3.4.1.4]

F.2.4.4.2 Ownship Data Requirements

The FAROA Ownship Data performance requirements are exactly the same as those required for the ASSA application as described in ASSA section E.2.3.4.2. This includes all the ownship performance requirements including:

- Minimum Ownship Data Requirements [ASSA section E.2.3.4.2.1]
- Desired Ownship Data Requirements [ASSA section E.2.3.4.2.2]

F.2.4.4.3 Other Miscellaneous Requirements for FAROA

F.2.4.4.3.1 Coverage Requirement

The FAROA application is potentially an active application when the ownship is on a runway, *near a runway* [see note] when on the ground, and near a runway on the final stages of an approach. FAROA is required to have the capability to indicate all traffic targets that are on or near a runway, and it may provide other surface traffic targets that are not "near" the runway (e.g., surface traffic on taxiways).

Note: "Near a runway" for FAROA is defined to include locations a) on the ground within 100 meters [to be reviewed] of the runway, and b) airborne within 3 NM of the runway and below 1000 feet height above the airport surface. The airborne region has been established to encompass traffic on the final stages of approach and initial stages of departure.

The minimum altitude coverage requirement is 1000 feet height above the airport surface. This region covers traffic aircraft on the final stages of approach, low missed approach aircraft, as well as the initial stages of departure. The minimum coverage region for each runway direction is 3 nautical miles, as this distance is sufficient to provide coverage at least 45 seconds prior to touchdown (even with fast final approach speeds up to 240 knots).

F.2.4.4.3.2 Aircraft/Vehicle FAROA Participation

There is no minimum number (or percentage) of vehicles moving within the coverage volume that must be equipped for the FAROA application. The FAROA application should be usable with any number of vehicles equipped. However, to gain the maximum benefit from the FAROA application, it is recommended that all vehicles moving in the coverage region be equipped. When all vehicles are equipped, the FAROA application provides the maximum benefit of both position and traffic situational awareness for all the vehicle operators. The FAROA application should reliably operate under the maximum traffic densities expected to occur.

F.2.4.4.3.3 Airport Map Database Requirements for FAROA

The FAROA airport map database requirements are the same as those required for the ASSA application as described in ASSA section E.2.3.4.3, except that the minimum set of "relevant" airport characteristics are the runways, rather than both runways and taxiways as specified for ASSA. This includes all database requirements including:

- Minimum Airport Map Database Characteristics [ASSA section E.2.3.4.3.3.1] with the exception that the minimum set of relevant characteristics for FAROA is just the runways, rather than both the runways and taxiways as is required for the ASSA application.
- Desired Airport Map Database Requirements [ASSA section E.2.3.4.3.3.2]

While not required as a minimum, it is highly desired that the FAROA database also include the taxiway "stubs" that intersect the runways.

F.2.4.5 Subsystem Integrity, Continuity, and Availability Requirements

The FAROA subsystem Integrity, Continuity, and Availability requirements are the same as those specified for ASSA in section E.2.3.5. This specifically includes the following:

- Subsystem Integrity Requirements [ASSA section E.2.3.5.1]
- Subsystem Continuity Requirements [ASSA section E.2.3.5.2]
- Subsystem Availability Requirements [ASSA section E.2.3.5.3]

[Editorial Note: Verify all the ASSA application section requirements references in the preceding sections once integrated into the ASA MASPS Appendices.]

F.2.5 Summary of Requirements

Section F.2.5 summarizes the high-level system performance requirements and defines high-level CDTI FAROA specific functional requirements.

F.2.5.1 Summary of FAROA Information Element Performance Requirements

Table F-9 below summarizes the FAROA System Information Element Performance requirements based upon the rationale given in Section F.2.4. These requirements are harmonized with the requirements for the ASSA application.

Table F-9 Summary of FAROA System Information Performance Requirements

Information Category	Information Quality	Normal Performance [1]		Degraded Performance [2]	Unacceptable Performance [3]
		Desirable	Minimum		
Target State Data – Accuracy Parameters	Navigation Accuracy Category – Position (NACp)	$NAC_p \geq 10$ *[EPU < 10 m , VEPU < 15 m]*	$NAC_p \geq 9$ *[EPU < 30 m, VEPU < 45 m]*	$NAC_p = 8$ *[EPU < 92.6 m]*	$NAC_p \leq 7$ *[EPU ≥ 92.6 m]*
	Navigation Accuracy Category – Velocity (NACv)	$NAC_v \geq 3$ *[EVU < 1 m/s, VEVU < 5 fps]*	$NAC_v \geq 2$ *[EVU < 3 m/s, VEVU < 15 fps]*	$NAC_v < 2$ *[HVE ≥ 3 m/s, VVE ≥ 15 fps]*	— [6]
	Heading Accuracy (95%) [11]	3°	10° [if provided]	—	> 10° [Note 16]
Target State Data – Integrity Parameters	Surveillance Integrity Level (SIL)	SIL ≥ 2 *[≥ 1-10^{-5}]*	SIL ≥ 1 *[≥ 1-10^{-3}]*	SIL = 0 *[Unknown]*	—
	Navigation Integrity Category (NIC)	NIC ≥ 10 *[R_C < 25.0 m, VPL < 37.5 m]*	NIC ≥ 9 *[R_C < 75.0 m, VPL < 112 m]*	NIC ≤ 8 *[R_C ≥ 75.0 m, VPL unknown or ≥ 112 m]*	—
	Maximum Delay to indicate integrity (NIC) change [10]	11 sec	12 sec	—	> 12 sec
Target State Data (SD) – Timing Parameters	Effective Update Rate (moving vehicles) [95% probability] for FAROA-relevant targets [13]	≤ 1 sec	≤ 2 sec	—	> 2 sec
	Effective Update Rate (non-moving vehicles) [95% probability] for FAROA-relevant targets [13]	≤ 5 sec	≤ 11 sec	—	> 11 sec
	Report Time Accuracy[8] (95%)	0.2 sec	1.0 sec	—	> 1.0 sec
	Latency Bound[9] of XMIT SD	1 sec	2 sec	—	> 2 sec
	Maximum coast time (moving vehicles)	2 sec	4 sec	15 sec	> 15 sec
	Maximum coast time (stationary vehicles)	6 sec	11 sec	26 sec	> 26 sec
Target Transmit Data Quality Parameters	Data Continuity [15]	≥ 99.7%	—	—	—
	Data Availability [15]	≥ 99.9%	—	—	—
	TBD (Will add other parameters to this list that will be encoded as part of SL)	TBD	—	—	—
	TBD	TBD	—	—	—
	TBD	TBD	—	—	—
	TBD	TBD	—	—	—
	Transmit Quality Level (TQL)	TQL ≥ 1	—	—	—
Own ship State Data [Minimum Requirements per DO-257A or later	Horizontal Position Accuracy	≤ 10 m	See DO-257A (or subsequent revision) [≤ 36 m Horizontal]	—	—
	Horizontal Velocity Accuracy	≤ 2m/s	—[14]	—	—
	Vertical Position Accuracy	≤ 30 m	—[14]	—	—

Table F-9 Summary of FAROA System Information Performance Requirements (continued)

Information Category	Information Quality	Normal Performance [1]		Degraded Performance [2]	Unacceptable Performance [3]
		Desirable	Minimum		
	Vertical Velocity Accuracy	≤ 6 m/s	—[14]	—	—
	Heading Accuracy – 95% [11]	10°	—[14]	—	—
	Horizontal Integrity containment radius, Rc	≤ 25 m	—[14]	—	—
	Vertical integrity containment bound	≤ 75 m	—[14]	—	—
	Navigation Integrity Level	$< 10^{-3}$	—[14]	—	—
	Latency	≤ 1.5 s	—[14]	—	—
	Report Time Accuracy	≤ 0.25 s	—[14]	—	—
Other Requirements	Airport Database	"*Medium*" Data as defined in DO-272 or other approved database. [See Note 18 for additional requirements.]	Database complies with either: 1) DO-257A (or subsequent revision) for the Aerodrome Moving Map Display (AMMD) application[12], or 2) "*Medium*" or Database as defined in DO-272(). [See Note 17 for additional requirements.]	—	Data base is not retrievable or unchecked by data integrity (e.g., CRC does not match)
	Coverage [4]	Ground: Entire Airport Airborne: within 1500 ft height above airport and 4-NM from all runway thresholds	Ground: On and near runways[5] Airborne: within 1000 ft height above airport and 3-NM from all runway thresholds	—	—
	Vehicle Participation	All Vehicles in the Coverage Volume	—	—	—

Notes for Table F-9:

1. *For FAROA "Normal Performance," all the requirements must simultaneously be met.*

2. *Degraded performance occurs when one or more of the conditions are satisfied, as the system degrades from initially meeting the "Normal Performance" requirements. If traffic vehicle state data only meets the degraded level of performance, then the traffic vehicle symbology must indicate that the traffic state information is in a degraded state on the CDTI.*

3. *Unacceptable performance for an FAROA traffic target occurs when one or more of the conditions are satisfied, as the system degrades from meeting the "Normal Performance" requirements. The FAROA system response depends upon what information has become unacceptable. If the heading or track accuracy performance is unacceptable, the traffic symbol is shown with a non-directional symbol. If the target* NAP_p *degrades to the level unacceptable performance, it is permissible to either remove the traffic target position symbol from the display, or provide an indication of the position uncertainty (e.g., 95% error region). The required response for all other parameters degrading to the unacceptable performance level is to remove the traffic symbol from the display.*

4. *Coverage includes all items for using FAROA. This includes, for example, airport database, navigation system, data links, etc. The FAROA application is potentially active when the ownship is on or near runways as well as on the final stages of an approach. Note that a companion application (ASSA) is potentially active when the ownship position is on the airport surface not near runways.*

5. *Airport "maneuvering area" as it is defined in ICAO Annex 14 [ref. 3, section 1].*

6. *"—" indicates no minimum requirement.*

7. *Integrity for the data elements is described in terms of "Critical," "Essential," and "Routine," as defined in ICAO Annex 14 [ref. 3, section 2.1.2]. As an alternative to meeting these requirements, data handling in the manner described in RTCA/DO-200() and RTCA/DO-201() or equivalent is sufficient to control the potential database errors to an acceptable level. There are no database feature errors that have been identified in this analysis for the FAROA supplemental use of the information that do not have sufficient hazard mitigation (see fault tree analysis in section F.1.1.1).*

8. *Precise time of day information is not needed for the FAROA application. However, relative time is needed to compensate for latency and to determine when information becomes stale.*

9. *The age of the state data that is used to position and orient the vehicles on the FAROA display is specified using two performance parameters. The first is the maximum latency from the ADS-B transmitting equipment for receiving relevant state data information and transmitting it as a state data report. The second metric, maximum coast time, limits the maximum age of applicability of the state data that can be used for generating a traffic vehicle position on the display.*

10. *The specified values for the maximum delay to indicate the change of integrity in the transmit state data are based upon allowing a 10-second time to alert for the navigation system plus the maximum latency bound time for the state data to be transmitted.*

11. *The heading accuracy is specified for the sensor. The requirement is as tight as specified for traffic targets to accommodate sufficiently accurate position compensation for latency using ground speed when on the surface. Additional display error is acceptable for orientating the position symbol on the CDTI .*

12. *It is the intent of this MASPS that current 10-9 airport databases could potentially be used for the FAROA application with appropriate procedures in place to correct database errors and significant feature position inaccuracies. An appropriate indication should be displayed on the CDTI indicating that the airport map has been drawn with a reduced quality of map data. If this indication is given, flight crews should be trained to be even more vigilant for potential database errors and inaccuracies.*

13. *FAROA relevant traffic targets are defined as surface vehicles on or near runways and airborne vehicles ≤ 3 nautical miles from the end of the closest runway.*

14. *There are no equipment performance requirements for this parameter per DO-257A for the Aerodrome Moving Map Display (AMMD) application.*

15. *The target state data continuity and data availability are quantified as part of the Transmit Quality Level parameter.*

16. *If valid heading or track information is unavailable, a non-directional symbol is required to be used that is not indicative of vehicle orientation, rather than removing the traffic target from the display.*

17. *Additional Minimum Database Requirements: The database features shall include runways. The reference datum for the database shall be WGS-84. At a minimum, the vertical position of the Airport Reference Point shall be provided with a 95% vertical accuracy ≤ 15 meters.*

18. *Additional Desired Database Characteristics: In addition to the minimum database requirements stated in note 17, the data integrity shall be at least "Routine" or equivalent data handling process (see note 7 for clarification). The horizontal requirements include a) accuracy ≤ 6m (95%), b) error bound ≤ 10m, and c) resolution ≤ 0.25m. The vertical requirements include a) accuracy ≤ 9m (95%), b) error bound ≤ 15m, and c) resolution ≤ 0.25m. At a minimum, the vertical position of the Airport Reference Point shall be provided.*

F.2.5.2 Subsystem Requirements

The subsystem integrity, continuity, and availability requirements to support the FAROA application are summarized in Table F-10.

Table F-10 Summary of Subsystem Integrity, Continuity, and Availability Requirements

Subsystem	Integrity (per hour)	Continuity (per hour)	Availability (per hour)
Single ship navigation	$1\text{-}10^{-3}$	—[1]	—[1]
Area navigation	$1\text{-}10^{-3}$	—[1]	—[1]
ADS-B Transmitter	$1\text{-}10^{-3}$	—[1]	—[1]
ADS-B/TIS-B Receiver	$1\text{-}10^{-3}$	—[1]	—[1]
FAROAP	$1\text{-}10^{-3}$	—[1]	—[1]
CDTI	$1\text{-}10^{-3}$	—[1]	—[1]

Note: *"—" indicates no minimum requirement.*

F.2.5.3 FAROA Application Functional Requirements

The high-level FAROA application functional requirements should be in accordance with the requirements and recommendations given below.

1. If the airport map database is determined to be valid (e.g., passes data integrity checks like CRC, age of database, etc.) and there are no other detected failures that would affect the integrity of the displayed information, then the airport map shall be displayed when the database information has characteristics within the field of view of the display. If the FAROA airport database is determined to be invalid, then the map information and traffic position symbology shall be removed from the CDTI.

   Note: *The "field of view" is the region depicted on the display. The field of view is normally positioned around the ownship vehicle position, but may optionally be panned such that the ownship position is outside the field of view (see #21).*

2. The display shall be capable of showing ownship position and relevant received traffic vehicle positions that appear within the display field of view that satisfy the normal or degraded display performance criteria given in Table F-9. User selectable filtering of relevant traffic targets is acceptable.

   Note: *"Relevant" traffic includes at a minimum all surface vehicles on or near runways and all airborne vehicles less than 1000 feet height above the airport surface and within 3 NM of the end of a runway.*

3. Ownship and traffic vehicle position symbology shall correspond to the underlying airport database map, when the map is displayed. When the map is not displayed (which should not be typical, but may happen because of flight crew de-cluttering selection), the traffic symbology shall be shown relative to the ownship.

   Note: *This means that the depiction of the vehicles and the underlying map must correspond. It does not mean that the vehicle positions should be snapped to the closest airport surface location useable for the vehicle. In fact, the latter is specifically prohibited (see #14 below).*

4. Ownship and traffic vehicle symbology shall be clearly discernable from airport map features (e.g., runways, taxiways, etc.).

5. The FAROA display shall have the capability to "zoom" such that 1-pixel ≤ 1 meter. This will provide an acceptable quantization error when it is necessary to zoom in to assess position and traffic situations.

6. Traffic vehicle information that meets the degraded performance specified in Table F-9 shall be indicated as degraded information. Degraded information for traffic vehicles shall be clearly discernable on the display from non-degraded information (e.g., use different color and a redundant means other than color).

   Note: *There should be some indication other than color about the information that the color is meant to convey, allowing the information to also be recognized by a person of impaired color vision. Color-coded information should be accompanied by another distinguishing characteristic such as shape, location, or text.*

7. When traffic vehicle information degrades to the unacceptable performance level specified in Table F-9, the following requirements apply. If the heading or track accuracy performance is unacceptable, the traffic symbol shall be shown with a non-directional symbol when all other conditions for continuing to display the symbol are satisfied. If the target NAP_p degrades to the level of unacceptable performance, then the target position symbol shall either be removed from the display or an indication shall be provided of the position uncertainty (e.g., 95% error region). When any other target vehicle parameters degrade to the unacceptable performance level, the traffic position symbol shall be removed from the display.

8. The display shall be updated to indicate the latest available information at least once per second.

9. The display shall have the capability to zoom out to encompass the entire airport such that the operator can see a big picture of the airport and traffic environment.

10. The aircraft symbology shall be able to scale when the display's zoom level is at or below 1 pixel = 1 meter.

11. For all displayed surface vehicles for which valid ground track or heading information is available, the vehicle symbology shall be directional to indicate the ground track or heading of the vehicles. For surface vehicles for which valid ground track or heading information is not available, the symbology shall not imply specific directionality (i.e., no sharply pointed symbols like a chevron).

12. For all displayed airborne vehicles for which valid ground track or North/East velocity information is available, the vehicle symbology shall be directional to indicate the ground track or velocity vector of the vehicles. For airborne vehicles for which valid ground track or velocity information is not available, the symbology shall not imply specific directionality (i.e., no sharply pointed symbols like a chevron).

13. "Data tags" show information about the traffic. The display shall have the capability to show the data tags and the capability to remove them for de-cluttering the display. If the data tags are shown, they shall be located in close proximity to their associated traffic symbol, move with it, and have a clear means of being associated with their appropriate traffic symbol. The data tag shall have the capability to include at least the following information, when the information is valid: a) traffic ID, b) ground speed (if on the ground), and c) velocity and altitude (if the vehicle is airborne).

14. The FAROA application shall not artificially adjust vehicle positions.

   Note: *This requirement is meant to preclude "snapping" the vehicle positions artificially to be on airport surfaces intended for vehicle movements. An example of artificial position adjustment includes snapping the displayed vehicle position to be on a taxiway or runway rather than on the grass between them. Artificially adjusting reported vehicle position increases the risk of providing misleading information to the flight crew.*

15. For airborne vehicles relevant to the FAROA application, their height above the airport shall be indicated in increments less than or equal to 100 feet.

16. The display shall have an indication of the database quality.

17. The displayed traffic and ownship vehicle positions shall be compensated for latency between the time that the position information was valid and the time that the information is displayed when valid velocity information of sufficient quality is available.

18. The FAROA application shall be able to process and display at least the closest 40 surface targets and at least the closest 10 airborne targets.

   Note: *The closest traffic targets are determined by their distance relative to ownship position.*

19. Displayed traffic target symbols shall indicate the quality of the displayed information (i.e., normal or degraded) based upon the information element performance requirements specified in Table F-9.

20. Displayed ownship and traffic target symbols shall be indicative of the vehicle size when valid size information is available and the display is sufficiently zoomed.

21. The display region shall be around the ownship position, unless the flight crew pans the field of view of the display to show a region other than around the ownship position. Note that the capability to pan the field of view is not a minimum requirement.

22. The display shall be oriented such that either ownship heading, ownship ground track, or north is up and the orientation shall be indicated.

F.2.6 Open Issues

When aircraft/vehicle is on the ground, DO-242A defines the required report parameters to include ground speed and heading, rather than north/east velocity. This could result in an increased position error resulting from the required latency compensation because heading is not necessarily indicative of the direction of motion (e.g., for aircraft being pushed back, for snow plows backing up, etc.). Suggest that a position paper is created to address this issue.

F.3 Supplemental Matter

F.3.1 Final Approach and Runway Occupancy Awareness Task Analysis (based on Commercial Flight Crew Operations)

F.3.1.1 Final Approach and Runway Occupancy Awareness

Items in **bold** are surface map related

- En Route Descent and Approach

Get Airport Information
    Record ATIS/AWOS data
    Determine runway and approach in use
Send " request gate" message (voice or ACARS)[5]
Receive gate assignment
Retrieve (paper) approach chart
Retrieve (paper or electronic[6]) taxi chart
Verify altimeters set
Verify pressurization set
Compute (or display FMS) landing weight
Set airspeed bugs
Set thrust index for GA thrust
Coordinate transfer of aircraft control (You have the airplane)
Brief approach procedure[7]
    Brief approach procedure chart data per SOP
Display SFC Map (north up mode?)
    Brief NOTAMS/hazards
    Brief planned exit taxiway
    Brief tentative taxi route
Reset MAP to desired airborne mode
Coordiante transfer of aircraft control (I have the airplane)
Call for Approach Checklist

[5] During approach preparation, PNF will continue to perform required radio communication. Coordination "off frequency" will normally not be required for FMS data entry. If PNF must go off frequency for any reason, normal coordination procedures continue to apply.
[6] Requirement for continued use of paper airport diagram is still TBD. EFB desired end result is that paper chart will NOT be required.
[7] If using the electronic map for briefing the surface operation prior to approach, a north up or "landing runway up" planning mode may be useful.

- Landing

Tune and identify navaids
Select landing gear down
Set flaps for landing
Reduce to final approach speed
Configure other systems for landing
    Fuel, Hydraulics, Pressurization, Etc.
Complete LANDING CHECKLIST
Display SFC map
Adjust map range to optimum view for FAROA task (TBD)
Select desired map scale and information level of detail optimum for FAROA task[8]
When runway is in view on the display, verify no traffic conflict
If traffic conflict exists and time permits, advise ATC[9]
If traffic conflict exists and conflict not resolved, execute a go around and advise ATC when able.

- After Landing

Exit runway
Call ground control for taxi clearance to ramp entry point when advised by local (tower) control.
Reconfigure aircraft and systems
    Landing lights/strobes, Speed brake down, Ignition set, Avionics set, Trim reset,
    Fuel, hyd, pressurization set
    Adjust map scale for taxi (default value?)[10]
Call for after landing checklist
Receive and record taxi clearance
Go to Route Planning

- Taxi

Go to Route Execution
Coordinate pilot off frequency (capt uses map to maintain situational awareness)
    Call ramp control for gate clearance
    Other company communications
    Other cabin communications
    Receive ramp control clearance for taxi to gate.
Advise ground control cleared to gate
Go to Route Planning
Go to Route Execution

[8] At what point in the final approach preparation for landing should map scale and level of detail be set? After the Landing Checklist is complete and prior to 500'AGL.
[9] Crew action when conflict is detected using display information is not dependent on ATC communication.
10 Initial map scale for taxi may be a default value, but the scale in use at any time will be task dependent. (See Route Execution)

- Route Planning (Adjust planning detail to actual requirements)

Verify/Determine present position
Determine destination
Review assigned route (e.g., "taxi Gate 3 via Echo & Zulu, hold short of Alpha and advise when you are cleared in")
OR
If no assigned route (e.g., "taxi to Gate 3"), develop route
Check route validity
Perform taxi briefing (adjust briefing detail to actual requirements)
  Review notams, other hazards
  Identify/brief turn points
  Identify/brief runway crossings/hold shorts.
  Identify/brief complex intersections
  Identify/brief stop point
  Identify sequence of ownship with respect to other traffic
  Adjust display range to see relevant traffic
    ID who you are following
    Select desired TTF
    ID to whom do you give way
    ID who's giving way to you and is he doing so
Go to Route Execution

- Route Execution

Verify clearance from obstacles, vehicles, persons, other aircraft.
Identify sequence of ownship with respect to others
  Adjust display range to see relevant traffic
  Verify traffic-to-follow
  Select desired traffic-to-follow
  ID to whom do you give way
  ID who's giving way to you and is he doing so
Release brakes and taxi to stop point
  Manage direction and speed (i.e., Drive the airplane)
  If sequenced behind traffic monitor traffic-to-follow
  Adjust display range to view next start-stop-turn point or runway crossing
Identify/announce turn points
  Identify/announce runway crossings
  Verify cross or hold short
  If crossing , verify/announce traffic status (eg "clear right, clear left, display clear")
Identify/announce stop point
Stop at stop point
If stopping for traffic, monitor traffic
When traffic is clear request/receive continuation clearance from ATC

F.3.2 Abbreviations

ADS-B	Automatic Dependent Surveillance-Broadcast
AGL	Above Ground Level
AMASS	Airport Movement Area Safety Systems
APU	Auxiliary Power Unit
ASDE-3	Airport Surveillance Detection Equipment version 3
ASDE-X	Airport Surveillance Detection Equipment X-band
ASSA	Airport Surface Situational Awareness
ATC	Air Traffic Control
CDTI	Cockpit Display of Traffic Information
FAA	Federal Aviation Administration
FAROA	Final Approach and Runway Occupancy Awareness
FMS	Flight Management System
HUD	Head-Up Display
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
LAAS	Local Area Augmentation System
MASPS	Minimum Aviation System Performance Standards
NM	Nautical Mile
NTSB	National Transportation Safety Board
PAPI	Precision Approach Path Indicator
PF	Pilot Flying
PFD	Primary Flight Display
PNF	Pilot Not Flying
RA	Resolution Advisory
RIPS	Runway Incursion Prevention System
RNAV	Area Navigation
SGS	Surface Guidance System
SMM	Surface Moving Map
TCAS	Traffic alert and Collision Avoidance System
TIS	Traffic Information Service
TIS-B	Traffic Information Service -Broadcast
WAAS	Wide Area Augmentation System

F.3.3 Definition of Terms

Automatic Dependent Surveillance-Broadcast (ADS-B)- A data link aircraft technology that sends aircraft information such as identification, category, position, velocity, and altitude. The information can be received and displayed by other appropriately equipped aircraft, vehicles, or ground stations.

Cockpit Display of Traffic Information (CDTI)- The pilot interface portion of a surveillance system. This interface includes the traffic display and all the controls that interact with such a display. The CDTI receives position information of traffic and own-ship from the airborne surveillance and separation assurance processing (ASSAP) function. The ASSAP receives such information from the surveillance sensors and own-ship position sensors.

Flight Crew- One or more cockpit crew members required for the operation of the aircraft.

Mixed Equipage- An environment where all aircraft do not have the same set of avionics. For example, some aircraft may transmit ADS-B and others may not, which could have implications for ATC and pilots. A mixed equipage environment will exist until all aircraft operating in a system have the same set of avionics

Desirable- The capability denoted as Desirable is not required to perform the procedure but would increase the utility of the operation.

Required- The capability denoted as Required is necessary to perform the desired application.

Traffic- One or more aircraft or vehicle(s).

Target- Traffic of particular interest to the flight crew.

Selected Target- Target that has become distinguishable from other traffic as a result of being selected.

Target Selection- Manual process of flight crew selecting a target.

F.3.4 References

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